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November 13, 2001

FORM PTO-1390 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE **TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371**		ATTORNEY'S DOCKET NUMBER **GRUNP117**
EXPRESS MAIL LABEL NO. ET942952673US		U.S. APPLICATION NO. **To Be Assigned** 10/018319
INTERNATIONAL APPLICATION NO. **PCT/EP00/04252**	INTERNATIONAL FILING DATE **10 May 2000 (10.05.2000)**	PRIORITY DATE CLAIMED **11 May 1999 (11.05.1999)**

TITLE OF INVENTION
FUEL CELL SYSTEM AND FUEL CELL FOR SUCH A SYSTEM

APPLICANT(S) FOR DO/EO/US
Manfred STEFENER, André PEINE, and Ulrich STIMMING

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9), and (21) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English-language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☒ is transmitted herewith.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)).
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ An English-language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English-language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 through 20 below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☒ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 USC 1.821.
18. ☐ A second copy of the published international application under 35 USC 154(d)(4).
19. ☐ A second copy of the English-language translation of the international application under 35 USC 154(d)(4).
20. ☒ Other items or information:

9 Sheets of drawings – figs. 1 - 11

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U.S. APPLICATION NO. 10/018319 To Be Assigned	INTERNATIONAL APPLICATION NO. PCT/EP00/04252			ATTORNEY'S DOCKET NUMBER GRUNP 117	
21. ☒ The following fees are submitted: **BASIC NATIONAL FEE (37 CFR 1.492(a)(1) - (5)):** Search Report has been prepared by the EPO or JPO .... **$890.00** International preliminary examination fee paid to USPTO (37 CFR 1.482) .... **$690.00** No International preliminary examination fee paid to USPTO (37 CFR 1.482) But international search fee paid to USPTO (37 CFR 1.455(a)(2)) .... **$710.00** Neither international preliminary examination fee (37 CFR 1.482) nor International search fee (37 CFR 1.455(a)(2)) paid to USPTO .... **$1040.00** International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2) - (4) **$100.00**				**CALCULATIONS**	PTO USE ONLY
ENTER APPROPRIATE BASIC FEE AMOUNT =				**$ 1040.00**	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 CFR 1.492(e))				**$ 130.00**	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	98 - 20 =	78	x $18.00	**$ 1404.00**	
Independent claims	4 - 3 =	1	x $84.00	**$ 84.00**	
MULTIPLE DEPENDENT CLAIM(S) (IF APPLICABLE)			+ $260.00	**$ 0.00**	
TOTAL OF ABOVE CALCULATIONS =				**$ 2658.00**	
Reduction of ½ for filing by small entity, if applicable. Small Entity Status is Asserted.				**$ 1329.00**	
SUBTOTAL =				**$ 1329.00**	
Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)) +				**$ 0.00**	
TOTAL NATIONAL FEE =				**$ 1329.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				**$ 0.00**	
TOTAL FEES ENCLOSED =				**$ 1329.00**	
				Amount to be Refunded:	$
				Charged:	

A check in the amount of <u>$ 1329.00</u> in payment of the above fees is enclosed. Authorization is hereby given to charge any additional fees or deficiencies, or to credit any overpayment, to Deposit Account No. 501998.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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Date: November 13, 2001

10018319 .042502

10/018319
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Group Art Unit:
Examiner:

In re Patent Application of:

Applicant	: STEFENER et al.	
U.S. Appln. No.	:	
International Appln. No.	: PCT/EP00/04252	
International Filing Date	: 10 May 2000	**PRELIMINARY AMENDMENT**
Priority Date Claimed	: 11 May 1999	
For	: FUEL CELL SYSTEM AND FUEL CELL FOR SUCH A SYSTEM	
Attorney Ref.	: GRUNP117	

Commissioner for Patents
Washington, D.C. 20231

Sir:

Preliminary to examination, please amend the application as follows:

IN THE SPECIFICATION:

Please enter the substitute specification submitted herewith.

IN THE CLAIMS:

Please cancel Claim 58 without prejudice or disclaimer to the subject matter recited therein, and amend the remaining claims to read as follows:

10018319 . 042502

1. (Amended) A system for supplying a consumer with electrical power, comprising:
a fuel cell device for generating electrical power, and
a fuel tank device for holding fuel to be supplied to the fuel cell device,
characterised by a disposal device for disposing of waste products resulting from operation of the fuel cell device.

2. (Amended) A system as claimed in Claim 1, in which the disposal device has a receptacle for holding the waste products.

3. (Amended) A system as claimed in Claim 2, in which the fuel tank device is designed such that it serves as the receptacle.

4. (Amended) A system as claimed in Claim 1, in which the disposal device has a filter device.

5. (Amended) A system as claimed in Claim 1, in which the disposal device has an ion exchange device.

6. (Amended) A system as claimed in Claim 4, in which the disposal device is designed to convert gases resulting from operation of the fuel cell device into at least one of liquid and solid substances.

7. (Amended) A system as claimed in Claim 1, further comprising a pump device, for supporting a fuel supply from the fuel tank device to the fuel cell device.

8. (Amended) A system as claimed in Claim 7, in which the fuel is supplied essentially by the pump device.

9. (Amended) A system as claimed in Claim 7, in which the pump device can be adjusted such that the quantity of fuel supplied by the pump device of the fuel cell

device effects a constant output of the fuel cell device, such that the output of the fuel cell device serves as output quantity.

10. (Amended) A system as claimed in Claim 1, in which the fuel cell device is a methanol fuel cell device.

11. (Amended) A system as claimed in Claim 10, in which the disposal device includes a filter device that converts carbon dioxide to a carbonate.

12. (Amended) A system as claimed in Claim 10, in which the disposal device includes an ion exchange device has an alkaline exchanger based on synthetic resin.

13. (Amended) A system as claimed in Claim 1, in which the fuel cell device is a hydrogen fuel cell device.

14. (Amended) A system as claimed in Claim 10, in which the fuel tank device is designed to hold a methanol-water mixture, further comprising an oxidising agent tank device to hold an oxidising agent.

15. (Amended) A system as claimed in Claim 14, further comprising a pump device, for supporting the supply of oxidising agent to the fuel cell device.

16. A system as claimed in Claim 15, in which the oxidising agent is essentially supplied by the pump device.

17. (Amended) A system as claimed in Claim 15, in which the pump device can be adjusted such that the quantity of oxidising agent supplied by the pump device of the fuel cell device effects a constant output of the fuel cell device, such that the output of the fuel cell device serves as an output quantity.

18. (Amended) A system as claimed in Claim 10, further comprising a pump device, for supporting the supply of oxidising agent to the fuel cell device, in which the pump device is designed as a ventilator device for supplying atmospheric air from the environment.

19. (Amended) A system as claimed in Claim 1, in which the fuel cell device, the fuel tank device, and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

20. (Amended) A system as claimed in Claim 1, in which the fuel cell device is arranged on the consumer side, and the fuel tank device and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

21. (Amended) A system for supplying a consumer with electrical power, comprising:
a fuel cell device for generating electrical power, and
a fuel tank device for housing the fuel to be supplied to the fuel cell device,
characterised in that the fuel cell device is provided on the consumer and the fuel tank device is a module that can be inserted into the consumer to supply power and removed from the consumer.

22. (Amended) A system as claimed in Claim 21, further comprising a pump device provided on the consumer side, for supporting a fuel supply from the fuel tank device to the fuel cell device.

23. (Amended) A system as claimed in Claim 22, in which the fuel is supplied essentially by the pump device.

24. (Amended) A system as claimed in Claim 22, in which the pump device can be adjusted such that a quantity of fuel supplied by the pump device of the fuel cell

device effects a constant output of the fuel cell device, such that the output of the fuel cell device serves as output quantity.

25. (Amended) A system as claimed in Claim 21, in which the fuel cell device is designed as a hydrogen fuel cell device.

26. (Amended) A system as claimed in Claim 21, further comprising a pump device provided on the consumer side, for supporting a supply of the oxidising agent to the fuel cell device.

27. A system as claimed in Claim 26, in which the supply of the oxidising agent is essentially supplied by the pump device.

28. (Amended) A system as claimed in Claim 26, in which the pump device can be adjusted such that the quantity of oxidising agent supplied by the pump device of the fuel cell device effects a constant output of the fuel cell device, such that the output of the fuel cell device serves as an output quantity.

29. (Amended) A system as claimed in Claim 26, in which the pump device is designed as a ventilator device for supplying atmospheric air from the environment.

30. (Amended) A fuel cell device, comprising:
a plurality of anode devices, and
a plurality of cathode devices, such that a corresponding one of said plurality of anode devices is associated with each said cathode device,
characterised in that the fuel cell device includes a substantially flat electrolyte device, such that each said anode device and its corresponding cathode device are arranged on opposite sides of the electrolyte device.

31. (Amended) A fuel cell device apparatus comprising at least two fuel cell devices, wherein each fuel cell device comprises:

a plurality of anode devices,

a plurality of cathode devices, such that a corresponding one of said plurality of anode devices is associated with each said cathode device, and

a plurality of electrolyte devices, such that

each said anode device and said corresponding cathode device are arranged on opposite sides of a corresponding electrolyte device and together form a single cell, and

all said single cells of each of the fuel cell devices are arranged on one plane.

32. (Amended) A fuel cell device as claimed in Claim 30, in which the anode devices are substantially the same size and shape as the corresponding cathode devices.

33. (Amended) A fuel cell device as claimed in Claim 30, further comprising ion-permeable current conductors, interconnected by a connection device and disposed between at least one of the electrolyte device and the anode devices, and the electrolyte device and the cathode devices.

34. (Amended) A fuel cell device as claimed in Claim 30, further comprising one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed on at least one of the anode devices and the cathode devices.

35. (Amended) A fuel cell device as claimed in Claim 30, further comprising one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed in at least one of the anode devices and the cathode devices.

36. (Amended) A fuel cell device as claimed in Claim 80, in which each current conductor has a braid or a perforated film.

37. (Amended) A fuel cell device as claimed in Claim 80, in which each current conductor comprises at least one of nickel, gold, platinum, and stainless steel.

38. (Amended) A fuel cell device as claimed in Claim 80, in which each current conductor is substantially the same size as one of the respective anode device and the respective cathode device.

39. (Amended) A fuel cell device as claimed in Claim 80, in which the connection device comprises strip conductors.

40. (Amended) A fuel cell device as claimed in Claim 39, in which the strip conductors are applied to the electrolyte device.

41. (Amended) A fuel cell device as claimed in Claim 40, in which the connection device comprises a strip conductor for at least one anode device and a strip conductor for at least one cathode device, such that the strip conductors are connected at an edge of the electrolyte device to a connector.

42. (Amended) A fuel cell device as claimed in Claim 40, in which the connection device for at least one anode device and at least one cathode device comprises a strip conductor that is guided from the anode side to the cathode side by the electrolyte device.

43. (Amended) A fuel cell device as claimed in Claim 80, further comprising a switch device that is designed to modify the connection device of the anode devices and the cathode devices of the fuel cell device, so that an electrical output generated by the fuel cell device can best adapt to the requisites of a consumer.

44. (Amended) A fuel cell device as claimed in Claim 43, in which the connection device comprises a strip conductor for at least one anode device and a strip conductor for at least one cathode device, such that the strip conductors are

connected at an edge of the electrolyte device to a connector, and in which the switch device has a connector that can be connected to the conductor at the edge of the electrolyte device.

45. (Amended) A fuel cell device as claimed in Claim 44, in which the connector comprises at least one plug board.

46. (Amended) A fuel cell device as claimed in Claim 30, in which the electrolyte device is a proton-conducting electrolyte film.

47. (Amended) A fuel cell device as claimed in Claim 30, in which the fuel cell device is a methanol fuel cell device, and the electrolyte device comprises nafion.

48. (Amended) A fuel cell device as claimed in Claim 30, in which the fuel cell device is a hydrogen fuel cell device, and the electrolyte device comprises nafion.

49. (Amended) A fuel cell device as claimed in Claim 30, in which the fuel cell device is manufactured by a surface-coating process.

50. (Amended) A fuel cell apparatus as claimed in Claim 31, in which each two adjacent said fuel cell devices are interconnected by an electrically insulating connection device, such that at least one of the following arrangements is provided:

each two adjacent fuel cell devices are arranged such that the anode devices of the first of these fuel cell devices are facing the anode devices of the second of these fuel cell devices, and

the cathode devices of the first of these fuel cell devices are facing the cathode devices of the second of these fuel cell devices, and

each connection device has a supply distribution structure for fuel to be supplied to the anode devices or oxidising agent to be supplied to the cathode devices.

51. (Amended) A fuel cell apparatus as claimed in Claim 31, in which each two adjacent said fuel cell devices are interconnected by an electrically insulating connection device, such that

each cathode side of a first of the two adjacent fuel cell devices of the anode device is facing the second of the two adjacent fuel cell devices, and

each connection device has a first supply distribution structure for fuel to be supplied to the anode devices and a second supply distribution structure for oxidising agent to be supplied to the cathode devices.

52. (Amended) A fuel cell apparatus as claimed in Claim 51, in which the connection device has conducting elements that are arranged such that the connection device electrically conductively connects each anode device of a first of two adjacent fuel cell devices to the cathode device facing the anode device of the second of two adjacent fuel cell devices.

53. (Amended) A fuel cell apparatus as claimed in Claim 50, in which the connection device includes strip conductors that are provided one of on and in the connection device.

54. (Amended) A fuel cell apparatus as claimed in Claim 53, in which the connection device comprises a first strip conductor for at least one anode device and a second strip conductor for at least one cathode device, such that the first and second strip conductors are connected at the edge of the connection device to a connector.

55. (Amended) A fuel cell apparatus as claimed in Claim 50, further comprising a casing in which the fuel cell apparatus is accommodated, in which the connector extends through a wall of the casing.

56. (Amended) A fuel cell device as claimed in Claim 30, which is designed as a low-temperature fuel cell device.

57. (Amended) A fuel cell device as claimed in Claim 30, which is designed to provide an electrical power output of less than one kW.

58. (Canceled)

Please add the following new claims:

59. (New) A system as claimed in Claim 5, in which the disposal device is designed to convert gases resulting from operation of the fuel cell device into at least one of liquid and solid substances.

60. (New) A system as claimed in Claim 8, in which the pump device can be adjusted such that the quantity of fuel supplied by the pump device of the fuel cell device effects a constant output of the fuel cell device, such that the output of the fuel cell device serves as output quantity.

61. (New) A system as claimed in claim 12, wherein the alkaline exchanger is a hydroxide ion exchanger.

62. (New) A system as claimed in Claim 13, in which the fuel tank device is designed to hold hydrogen, further comprising an oxidising agent tank device to hold an oxidising agent.

63. (New) A system as claimed in claim 14, wherein the oxidising agent is one of oxygen and hydrogen peroxide.

64. (New) A system as claimed in claim 62, wherein the oxidising agent is one of oxygen and hydrogen peroxide.

65. (New) A system as claimed in Claim 62, further comprising a pump device, for supporting the supply of oxidising agent to the fuel cell device.

66. (New) A system as claimed in Claim 16, in which the pump device can be adjusted such that the quantity of oxidising agent supplied by the pump device of the fuel cell device effects a constant output of the fuel cell device, such that the output of the fuel cell device serves as an output quantity.

67. (New) A system as claimed in Claim 13, further comprising a pump device, for supporting the supply of oxidising agent to the fuel cell device, in which the pump device is designed as a ventilator device for supplying atmospheric air from the environment.

68. (New) A system as claimed in Claim 7, in which the fuel cell device, the fuel tank device, the pump device for the fuel, and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

69. (New) A system as claimed in Claim 14, in which the fuel cell device, the fuel tank device, the oxidising agent tank device, and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

70. (New) A system as claimed in Claim 15, in which the fuel cell device, the fuel tank device, the pump device for the oxidising agent, the oxidising agent tank device, and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

71. (New) A system as claimed in Claim 7, in which the fuel cell device and the pump device for the fuel are arranged on the consumer side, and the fuel tank device and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

72. (New) A system as claimed in Claim 14, in which the fuel cell device is arranged on the consumer side, and the fuel tank device, the oxidising agent tank device, and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

73. (New) A system as claimed in Claim 15, in which the fuel cell device and the pump device for the oxidising agent is are arranged on the consumer side, and the fuel tank device, the oxidising agent tank device, and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

74. (New) A system as claimed in Claim 23, in which the pump device can be adjusted such that a quantity of fuel supplied by the pump device of the fuel cell device effects a constant output of the fuel cell device, such that the output of the fuel cell device serves as output quantity.

75. (New) A system as claimed in Claim 27, in which the pump device can be adjusted such that the quantity of oxidising agent supplied by the pump device of the fuel cell device effects a constant output of the fuel cell device, such that the output of the fuel cell device serves as an output quantity.

76. (New) A fuel cell apparatus as claimed in Claim 31, in which the anode devices are substantially the same size and shape as the corresponding cathode devices.

77. (New) A fuel cell apparatus as claimed in Claim 31, further comprising ion-permeable current conductors, interconnected by a connection device and disposed between at least one of the electrolyte devices and the anode devices, and the electrolyte devices and the cathode devices.

78. (New) A fuel cell apparatus as claimed in Claim 31, further comprising one of fuel-permeable and oxidant-permeable current conductors, interconnected by a

connection device and disposed on at least one of the anode devices and the cathode devices.

79. (New) A fuel cell device as claimed in Claim 30, further comprising one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed in at least one of the anode devices and the cathode devices.

80. (New) A fuel cell device as claimed in Claim 30, further comprising one of:

ion-permeable current conductors, interconnected by a connection device and disposed between at least one of

the electrolyte device and the anode devices, and

the electrolyte device and the cathode devices;

one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed on at least one of the anode devices and the cathode devices; and

one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed in at least one of the anode devices and the cathode devices.

81. (New) A fuel cell apparatus as claimed in Claim 31, further comprising one of:

ion-permeable current conductors, interconnected by a connection device and disposed between at least one of

the electrolyte device and the anode devices, and

the electrolyte device and the cathode devices;

one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed on at least one of the anode devices and the cathode devices; and

one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed in at least one of the anode devices and the cathode devices.

82. (New) A fuel cell apparatus as claimed in Claim 81, in which each current conductor has a braid or a perforated film.

83. (New) A fuel cell apparatus as claimed in Claim 81, in which each current conductor comprises at least one of nickel, gold, platinum, and stainless steel.

84. (New) A fuel cell apparatus as claimed in Claim 81, in which each current conductor is substantially the same size as one of the respective anode device and the respective cathode device.

85. (New) A fuel cell apparatus as claimed in Claim 81, in which the connection device comprises strip conductors.

86. (New) A fuel cell apparatus as claimed in Claim 85, in which the strip conductors are applied to the electrolyte device.

87. (New) A fuel cell apparatus as claimed in Claim 86, in which the connection device comprises a strip conductor for at least one anode device and a strip conductor for at least one cathode device, such that the strip conductors are connected at an edge of the electrolyte device to a connector.

88. (New) A fuel cell apparatus as claimed in Claim 86, in which the connection device for at least one anode device and at least one cathode device comprises a strip conductor that is guided from the anode side to the cathode side by the electrolyte device.

89. (New) A fuel cell apparatus as claimed in Claim 81, further comprising a switch device that is designed to modify the connection device of the anode devices and the cathode devices of the at least two fuel cell devices, so that an electrical output generated by the fuel cell device can best adapt to the requisites of a consumer.

90. (New) A fuel cell apparatus as claimed in Claim 89, in which the connection device comprises a strip conductor for at least one anode device and a strip conductor for at least one cathode device, such that the strip conductors are connected at an edge of the electrolyte device to a connector, and in which the switch device has a connector that can be connected to the conductor at the edge of the electrolyte device.

91. (New) A fuel cell apparatus as claimed in Claim 90, in which the connector comprises at least one plug board.

92. (New) A fuel cell apparatus as claimed in Claim 31, in which the electrolyte device is a proton-conducting electrolyte film.

93. (New) A fuel cell apparatus as claimed in Claim 31, in which the fuel cell devices are methanol fuel cell devices, and the electrolyte device comprises nafion.

94. (New) A fuel cell apparatus as claimed in Claim 31, in which the fuel cell devices are hydrogen fuel cell devices, and the electrolyte device comprises nafion.

95. (New) A fuel cell apparatus as claimed in Claim 31, in which the fuel cell devices are manufactured by a surface-coating process.

96. (New) A fuel cell device as claimed in Claim 49, wherein the surface-coating process is one of a semi-conductor technology processes and a electroplating processes.

97. (New) A fuel cell apparatus as claimed in Claim 95, wherein the surface-coating process is one of a semi-conductor technology processes and a electroplating processes.

98. (New) A fuel cell apparatus as claimed in Claim 31, which is designed as a low-temperature fuel cell device.

99. (New) A fuel cell apparatus as claimed in Claim 31, which is designed to provide an electrical power output of less than one kW.

REMARKS

A substitute specification is submitted herewith so as to present the application in the preferred format for examination according to the MPEP. Based on knowledge and belief, no new matter is added by the substitute specification. The claims are amended to eliminate multiple dependencies, and to present the claims in the preferred format for examination. Claims 1-57 and 59-99 are now pending in the application. Claims 1, 21, 30, and 31 are the independent claims. Please enter the claim amendments prior to calculating the filing fee. Examination of the amended application is respectfully requested.

Respectfully submitted,

November 13, 2001
Date

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<u>VERSION WITH MARKINGS TO SHOW CHANGES MADE</u>

1. (Amended) A system [(10; 30; 40)] for supplying a consumer with electrical power, comprising:

   a fuel cell device [(11; 31; 41)] for generating electrical power, <u>and</u>

   a fuel tank device [(12; 32; 42)] for holding [the] fuel to be supplied to the fuel cell device,

   characterised by

   a disposal device [(13; 33-1, 33-2; 43)] for disposing of [the] waste products resulting from operation of the fuel cell device.

2. (Amended) A system as claimed in Claim 1, in which the disposal device [(33-2; 43)] has a receptacle for holding the waste products.

3. (Amended) A system as claimed in Claim 2, in which the fuel tank device [(12; 32)] is designed such that it serves as [a] <u>the</u> receptacle.

4. (Amended) A system as claimed in [any one of Claims] <u>Claim</u> 1 [to 3], in which the disposal device [(13)] has a filter device.

5. (Amended) A system as claimed in [any one of Claims] <u>Claim</u> 1 [to 3], in which the disposal device [(33-1)] has an ion exchange device.

6. (Amended) A system as claimed in Claim 4 [or 5], in which the disposal device [(13; 33-1)] is designed to convert gases resulting from operation of the fuel cell device into <u>at least one of</u> liquid and[/or] solid substances.

7. (Amended) A system as claimed in [any one of the foregoing claims having] Claim 1, further comprising a pump device [(14; 34; 44)], [preferably a miniature pump,] for supporting [the] a fuel supply from the fuel tank device [(12; 32; 42)] to the fuel cell device [(11; 31; 41)].

8. (Amended) A system as claimed in Claim 7, in which the fuel is supplied essentially by the pump device [(14; 34; 44)].

9. (Amended) A system as claimed in Claim 7 [or 8], in which the pump device [(14; 34; 44)] can be adjusted such that the quantity of fuel supplied by the pump device [(14; 34; 44)] of the fuel cell device [(11; 31; 41)] effects a constant output of the fuel cell device [(11; 31; 41)], such that the output of the fuel cell device serves as output quantity.

10. (Amended) A system as claimed in [any one of the foregoing claims] Claim 1, in which the fuel cell device [(11; 31)] is [designed as] a methanol fuel cell device.

11. (Amended) A system as claimed in Claim 10 [in conjunction with Claim 4], in which the disposal device includes a filter device [(13) is provided to convert] that converts carbon dioxide to a carbonate.

12. (Amended) A system as claimed in Claim 10 [in conjunction with Claim 5], in which the disposal device includes an ion exchange device [(33-1)] has an alkaline exchanger[, preferably a hydroxide ion exchanger,] based on synthetic resin.

13. (Amended) A system as claimed in [any one of Claims] Claim 1 [to 9], in which the fuel cell device [(41)] is [designed as] a hydrogen fuel cell device.

14. (Amended) A system as claimed in [any one of Claims] Claim 10 [to 13], in which the fuel tank device is designed to hold a methanol-water mixture [(32) or hydrogen

(42)], [and] further comprising an oxidising agent tank device [is provided] to hold an oxidising agent [(35; 45), preferably oxygen or hydrogen peroxide].

15. (Amended) A system as claimed in [any one of the foregoing claims having] Claim 14, further comprising a pump device [(16; 36; 46)], [preferably a miniature pump,] for supporting the supply of oxidising agent to the fuel cell device [(11; 31; 41)].

16. A system as claimed in Claim 15, in which the oxidising agent is essentially supplied by the pump device.

17. (Amended) A system as claimed in Claim 15 [or 16], in which the pump device [(16; 36; 46)] can be adjusted such that the quantity of oxidising agent supplied by the pump device [(16; 36; 46)] of the fuel cell device [(11; 31; 41)] effects a constant output of the fuel cell device [(11; 31; 41)], such that the output of the fuel cell device serves as an output quantity.

18. (Amended) A system as claimed in [any one of Claims 15 to 17 in conjunction with any one of Claims] Claim 10 [to 13], further comprising a pump device, for supporting the supply of oxidising agent to the fuel cell device, in which the pump device is designed as a ventilator device for supplying atmospheric air from the environment.

19. (Amended) A system as claimed in [any one of Claims] Claim 1 [to 18], in which the fuel cell device, the fuel tank device, [if necessary the pump device for the fuel and/or for the oxidising agent, is necessary the tank device for holding the oxidising agent] and the disposal device are designed as a module [which] that can be inserted into the consumer to supply power and removed from the consumer.

20. (Amended) A system as claimed in [any one of Claims] Claim 1 [to 18], in which the fuel cell device [and if necessary the pump device for the fuel and/or for the oxidising agent] is [or are] arranged on the consumer side, and the fuel tank

device[, if necessary the tank device for holding the oxidising agent] and the disposal device are designed as a module [which] that can be inserted into the consumer to supply power and removed from the consumer.

21. (Amended) A system [(20)] for supplying a consumer with electrical power, comprising:

a fuel cell device [(21)] for generating electrical power, and

a fuel tank device [(22)] for housing the fuel to be supplied to the fuel cell device,

characterised in that

the fuel cell device [(21)] is provided on the consumer and the fuel tank device [(22)] is [designed as] a module [which] that can be inserted into the consumer to supply power and removed from the consumer.

22. (Amended) A system as claimed in Claim 21, further comprising [with] a pump device [(24)] provided on the consumer side[, preferably a miniature pump], for supporting [the] a fuel supply from the fuel tank device [(22)] to the fuel cell device [(22)].

23. (Amended) A system as claimed in Claim 22, in which the fuel is supplied essentially by the pump device [(24)].

24. (Amended) A system as claimed in Claim 22 [or 23], in which the pump device [(24)] can be adjusted such that [the] a quantity of fuel supplied by the pump device [(24)] of the fuel cell device [(21)] effects a constant output of the fuel cell device [(21)], such that the output of the fuel cell device serves as output quantity.

25. (Amended) A system as claimed in [any one of Claims] Claim 21 [to 24], in which the fuel cell device [(21)] is designed as a hydrogen fuel cell device.

26. (Amended) A system as claimed in [any one of Claims] Claim 21, further comprising [to 25 with] a pump device [(26)] provided on the consumer side, [preferably a miniature pump,] for supporting [the] a supply of the oxidising agent to the fuel cell device [(21)].

27. A system as claimed in Claim 26, in which the supply of the oxidising agent is essentially supplied by the pump device.

28. (Amended) A system as claimed in Claim 26 [or 27], in which the pump device [(26)] can be adjusted such that the quantity of oxidising agent supplied by the pump device [(26)] of the fuel cell device [(21)] effects a constant output of the fuel cell device [(21)], such that the output of the fuel cell device serves as an output quantity.

29. (Amended) A system as claimed in [any one of Claims] Claim 26 [to 29], in which the pump device [(26)] is designed as a ventilator device for supplying atmospheric air from the environment.

30. (Amended) A fuel cell device, [(50)] comprising: [at least one fuel cell device with]

a plurality of anode devices [(51)], and

a plurality of cathode devices [(52)], such that a corresponding one of said plurality of anode [device] devices is [assigned to] associated with each said cathode device,

characterised in that

[each] the fuel cell device [has] includes a substantially flat electrolyte device [(55)], such that each said anode device [(51)] and its corresponding cathode device [(52)] are arranged on opposite sides of the electrolyte device.

31. (Amended) A fuel cell device apparatus [(90)] comprising at least two fuel cell devices, [(90a, 90b)] wherein each fuel cell device comprises: [having]

a plurality of anode devices [(91)],

a plurality of cathode devices [(92)], such that a corresponding one of said plurality of anode [device] devices is [assigned to] associated with each said cathode device, and

a plurality of electrolyte devices [(95)], such that

each said anode device [(91)] and [a] said corresponding cathode device [(92)] are arranged on opposite sides of a corresponding electrolyte device [(95)] and together form a single cell, and

all said single cells of [a] each of the fuel cell [device] devices are arranged on one plane.

32. (Amended) A fuel cell device as claimed in Claim 30 [or 31], in which [corresponding] the anode devices [(51) and] are substantially the same size and shape as the corresponding cathode devices [(52) are the same size and shape].

33. (Amended) A fuel cell device as claimed in [any one of Claims] Claim 30 [to 32], [in which] further comprising ion-permeable[, preferably proton-permeable,] current conductors [(56d)], [which are] interconnected by a connection device[, are provided] and disposed between at least one of the electrolyte device[(s)] and the anode devices, and[/or between] the electrolyte device[(s)] and the cathode devices.

34. (Amended) A fuel cell device as claimed in [any one of Claims] Claim 30 [to 33], [in which] further comprising one of fuel-permeable [or] and oxidant-permeable current conductors [(86)], [which are] interconnected by a connection device[, are provided] and disposed on at least one of the anode devices and[/or] the cathode devices.

35. (Amended) A fuel cell device as claimed in [any one of Claims] Claim 30 [to 34], [in which] further comprising one of fuel-permeable [or] and oxidant-permeable current conductors [(116)], [which are] interconnected by a connection device[, are provided] and disposed in at least one of the anode devices and[/or in] the cathode devices.

36. (Amended) A fuel cell device as claimed in [any one of Claims 33 to 35] Claim 80, in which each current conductor [(56d; 86; 116)] has a braid or a perforated film.

37. (Amended) A fuel cell device as claimed in [any one of Claims 33 to 36] Claim 80, in which each current conductor comprises at least one of nickel, gold, platinum, and[/or] stainless steel.

38. (Amended) A fuel cell device as claimed in [any one of Claims 33 to 37] Claim 80, in which each current conductor [(56d; 86; 116)] is [approximately] substantially the same size as one of the respective anode device [assigned thereto or] and the respective cathode device [assigned thereto].

39. (Amended) A fuel cell device as claimed in [any one of Claims 33 to 38] Claim 80, in which the connection device [strip] comprises strip conductors.

40. (Amended) A fuel cell device as claimed in Claim 39, in which the strip conductors [(54)] are applied to the electrolyte device.

41. (Amended) A fuel cell device as claimed in Claim [39 or] 40, in which the connection device comprises a strip conductor for at least one anode device [(56a; 66a)] and a strip conductor for at least one cathode device [(56b; 66b)], such that the strip conductors are connected at [the] an edge of the electrolyte device to a connector [(67a; 67b)].

42. (Amended) A fuel cell device as claimed in [any one of Claims 39 to 41] Claim 40, in which the connection device for at least one anode device and at least one cathode device comprises a strip conductor [(56c) which] that is guided from the anode side to the cathode side by the electrolyte device.

43. (Amended) A fuel cell device as claimed in [any one of Claims 33 to 42] Claim 80, [with] further comprising a switch device [(69) which] that is designed to modify the connection device of the anode devices and the cathode devices of [at least one or at least two] the fuel cell [devices] device, so that [the] an electrical output generated by the fuel cell device can best adapt [(U, I)] to the requisites of a consumer.

44. (Amended) A fuel cell device as claimed in Claim 43 [in conjunction with Claim 41], in which the connection device comprises a strip conductor for at least one anode device and a strip conductor for at least one cathode device, such that the strip conductors are connected at an edge of the electrolyte device to a connector, and in which the switch device has a connector [which] that can be connected to the [connector] conductor at the edge of the electrolyte device.

45. (Amended) A fuel cell device as claimed in Claim 44, in which the connector comprises [a] at least one plug board [or several plug boards].

46. (Amended) A fuel cell device as claimed in [any one of Claims] Claim 30 [to 45], in which the electrolyte device is [provided in the form of] a proton-conducting electrolyte film.

47. (Amended) A fuel cell device as claimed in [any one of Claims] Claim 30 [to 46], in which the fuel cell [devices are] device is a methanol fuel cell [devices] device, and the electrolyte device comprises nafion.

48. (Amended) A fuel cell device as claimed in [any one of Claims] Claim 30 [to 46], in which the fuel cell [devices are] device is a hydrogen fuel cell [devices] device, and the electrolyte device comprises nafion.

49. (Amended) A fuel cell device as claimed in [any one of Claims] Claim 30 [to 48], in which the fuel cell [devices are] device is manufactured by a surface-coating [processes, preferably semi-conductor technology processes and/or electroplating processes] process.

50. (Amended) A fuel cell apparatus [device (80; 90)] as claimed in [any one of Claims 30 to 49 with at least two fuel cell devices (80a, 80b, 80c)] Claim 31, in which each two adjacent said fuel cell devices [(80a, 80b or 80b, 80c)] are interconnected by an electrically insulating connection device [(88a or 88b)], such that

at least one of the following arrangements is provided:

each two adjacent fuel cell devices [(80a, 80b)] are arranged such that the anode devices [(81)] of the first of these fuel cell devices [(80a)] are facing the anode devices [(81)] of the second of these fuel cell devices [(80b)], and[/or]

the cathode devices [(82)] of the first of these fuel cell devices [(80b)] are facing the cathode devices [(82)] of the second of these fuel cell devices [(80c)], and

each connection device [(88a or 88b)] has a supply distribution structure [(89a or 89b)] for [the] fuel [(B)] to be supplied to the anode devices or [the] oxidising agent [(O)] to be supplied to the cathode devices.

51. (Amended) A fuel cell apparatus [device (70)] as claimed in [any one of Claims 30 to 49 with at least two fuel cell devices (70a, 70b)] Claim 31, in which each two adjacent said fuel cell devices [(70a, 70b)] are interconnected by an electrically insulating connection device [(77a)], such that

each cathode side [(72)] of a first of the two adjacent fuel cell devices [(70b)] of the anode device [(71)] is facing the second of the two adjacent fuel cell devices [(70a)], and

each connection device [(77a)] has a first supply distribution structure [(79a)] for [the] fuel [(B)] to be supplied to the anode devices [(71)] and a second supply distribution structure [(79b)] for [the] oxidising agent [(O)] to be supplied to the cathode devices [(72)].

52. (Amended) A fuel cell apparatus [device] as claimed in Claim 51, in which the connection device [(107)] has conducting elements [(110a; 110b) which] that are arranged such that [it] the connection device electrically conductively connects each anode device [(101)] of a first of two adjacent fuel cell devices [(100a)] to the cathode device [(102)] facing [it] the anode device of the second of two adjacent fuel cell devices [(100b)].

53. (Amended) A fuel cell apparatus [device] as claimed in [any one of Claims] Claim 50 [to 52 in conjunction with Claim 39], in which the connection device includes strip conductors that are provided one of on [or] and in the connection device.

54. (Amended) A fuel cell apparatus [device] as claimed in Claim 53, in which the connection device comprises a first strip conductor for at least one anode device and a second strip conductor for at least one cathode device, such that the first and second strip conductors are connected at the edge of the connection device to a connector.

55. (Amended) A fuel cell apparatus [device] as claimed in [any one of Claims] Claim 50, further comprising [to 54 with] a casing in which the fuel cell apparatus [device] is accommodated, in which the connector extends through a wall of the casing.

56. (Amended) A fuel cell device as claimed in [any one of Claims] Claim 30 [to 55], which is designed as a low-temperature fuel cell device.

57. (Amended) A fuel cell device as claimed in [any one of Claims] Claim 30 [to 56], which is designed to provide an electrical power output of less than one kW.

58. (Canceled)

59. (New) A system as claimed in Claim 5, in which the disposal device is designed to convert gases resulting from operation of the fuel cell device into at least one of liquid and solid substances.

60. (New) A system as claimed in Claim 8, in which the pump device can be adjusted such that the quantity of fuel supplied by the pump device of the fuel cell device effects a constant output of the fuel cell device, such that the output of the fuel cell device serves as output quantity.

61. (New) A system as claimed in claim 12, wherein the alkaline exchanger is a hydroxide ion exchanger.

62. (New) A system as claimed in Claim 13, in which the fuel tank device is designed to hold hydrogen, further comprising an oxidising agent tank device to hold an oxidising agent.

63. (New) A system as claimed in claim 14, wherein the oxidising agent is one of oxygen and hydrogen peroxide.

64. (New) A system as claimed in claim 62, wherein the oxidising agent is one of oxygen and hydrogen peroxide.

65. (New) A system as claimed in Claim 62, further comprising a pump device, for supporting the supply of oxidising agent to the fuel cell device.

66. (New) A system as claimed in Claim 16, in which the pump device can be adjusted such that the quantity of oxidising agent supplied by the pump device of the fuel cell device effects a constant output of the fuel cell device, such that the output of the fuel cell device serves as an output quantity.

67. (New) A system as claimed in Claim 13, further comprising a pump device, for supporting the supply of oxidising agent to the fuel cell device, in which the pump device is designed as a ventilator device for supplying atmospheric air from the environment.

68. (New) A system as claimed in Claim 7, in which the fuel cell device, the fuel tank device, the pump device for the fuel, and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

69. (New) A system as claimed in Claim 14, in which the fuel cell device, the fuel tank device, the oxidising agent tank device, and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

70. (New) A system as claimed in Claim 15, in which the fuel cell device, the fuel tank device, the pump device for the oxidising agent, the oxidising agent tank device,

and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

71. (New) A system as claimed in Claim 7, in which the fuel cell device and the pump device for the fuel are arranged on the consumer side, and the fuel tank device and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

72. (New) A system as claimed in Claim 14, in which the fuel cell device is arranged on the consumer side, and the fuel tank device, the oxidising agent tank device, and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

73. (New) A system as claimed in Claim 15, in which the fuel cell device and the pump device for the oxidising agent is are arranged on the consumer side, and the fuel tank device, the oxidising agent tank device, and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

74. (New) A system as claimed in Claim 23, in which the pump device can be adjusted such that a quantity of fuel supplied by the pump device of the fuel cell device effects a constant output of the fuel cell device, such that the output of the fuel cell device serves as output quantity.

75. (New) A system as claimed in Claim 27, in which the pump device can be adjusted such that the quantity of oxidising agent supplied by the pump device of the fuel cell device effects a constant output of the fuel cell device, such that the output of the fuel cell device serves as an output quantity.

76. (New) A fuel cell apparatus as claimed in Claim 31, in which the anode devices are substantially the same size and shape as the corresponding cathode devices.

77. (New) A fuel cell apparatus as claimed in Claim 31, further comprising ion-permeable current conductors, interconnected by a connection device and disposed between at least one of the electrolyte devices and the anode devices, and the electrolyte devices and the cathode devices.

78. (New) A fuel cell apparatus as claimed in Claim 31, further comprising one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed on at least one of the anode devices and the cathode devices.

79. (New) A fuel cell device as claimed in Claim 30, further comprising one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed in at least one of the anode devices and the cathode devices.

80. (New) A fuel cell device as claimed in Claim 30, further comprising one of:

ion-permeable current conductors, interconnected by a connection device and disposed between at least one of

the electrolyte device and the anode devices, and

the electrolyte device and the cathode devices;

one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed on at least one of the anode devices and the cathode devices; and

one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed in at least one of the anode devices and the cathode devices.

81. (New) A fuel cell apparatus as claimed in Claim 31, further comprising one of:

ion-permeable current conductors, interconnected by a connection device and disposed between at least one of

the electrolyte device and the anode devices, and

the electrolyte device and the cathode devices;

one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed on at least one of the anode devices and the cathode devices; and

one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed in at least one of the anode devices and the cathode devices.

82. (New) A fuel cell apparatus as claimed in Claim 81, in which each current conductor has a braid or a perforated film.

83. (New) A fuel cell apparatus as claimed in Claim 81, in which each current conductor comprises at least one of nickel, gold, platinum, and stainless steel.

84. (New) A fuel cell apparatus as claimed in Claim 81, in which each current conductor is substantially the same size as one of the respective anode device and the respective cathode device.

85. (New) A fuel cell apparatus as claimed in Claim 81, in which the connection device comprises strip conductors.

86. (New) A fuel cell apparatus as claimed in Claim 85, in which the strip conductors are applied to the electrolyte device.

87. (New) A fuel cell apparatus as claimed in Claim 86, in which the connection device comprises a strip conductor for at least one anode device and a strip conductor for at least one cathode device, such that the strip conductors are connected at an edge of the electrolyte device to a connector.

88. (New) A fuel cell apparatus as claimed in Claim 86, in which the connection device for at least one anode device and at least one cathode device comprises a strip conductor that is guided from the anode side to the cathode side by the electrolyte device.

89. (New) A fuel cell apparatus as claimed in Claim 81, further comprising a switch device that is designed to modify the connection device of the anode devices and the cathode devices of the at least two fuel cell devices, so that an electrical output generated by the fuel cell device can best adapt to the requisites of a consumer.

90. (New) A fuel cell apparatus as claimed in Claim 89, in which the connection device comprises a strip conductor for at least one anode device and a strip conductor for at least one cathode device, such that the strip conductors are connected at an edge of the electrolyte device to a connector, and in which the switch device has a connector that can be connected to the conductor at the edge of the electrolyte device.

91. (New) A fuel cell apparatus as claimed in Claim 90, in which the connector comprises at least one plug board.

92. (New) A fuel cell apparatus as claimed in Claim 31, in which the electrolyte device is a proton-conducting electrolyte film.

93. (New) A fuel cell apparatus as claimed in Claim 31, in which the fuel cell devices are methanol fuel cell devices, and the electrolyte device comprises nafion.

94. (New) A fuel cell apparatus as claimed in Claim 31, in which the fuel cell devices are hydrogen fuel cell devices, and the electrolyte device comprises nafion.

95. (New) A fuel cell apparatus as claimed in Claim 31, in which the fuel cell devices are manufactured by a surface-coating process.

96. (New) A fuel cell device as claimed in Claim 49, wherein the surface-coating process is one of a semi-conductor technology processes and a electroplating processes.

97. (New) A fuel cell apparatus as claimed in Claim 95, wherein the surface-coating process is one of a semi-conductor technology processes and a electroplating processes.

98. (New) A fuel cell apparatus as claimed in Claim 31, which is designed as a low-temperature fuel cell device.

99. (New) A fuel cell apparatus as claimed in Claim 31, which is designed to provide an electrical power output of less than one kW.

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FUEL CELL SYSTEM AND FUEL CELL FOR SUCH A SYSTEM

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Field of the Invention

The present invention relates to a system for supplying a consumer with electrical power using a fuel cell device for generating electrical power, and a fuel tank device for holding fuel to be supplied to the fuel cell device.

The invention also relates to fuel cells for such a system, in particular a fuel cell device comprising at least one fuel cell device having a plurality of anode devices, and a plurality of cathode devices, where each cathode device is assigned a corresponding anode device.

In addition, the invention relates to a stack of such fuel cells (hereinbelow also called fuel cell stacks).

Background of the Invention

Systems with fuel cells of the abovementioned type as well as fuel cells of the abovementioned type for such systems are known in the prior art.

These known fuel cell systems are essentially restricted to the high-performance application range of several kW. Examples of fuel cell systems are found in the automobile industry or in power plant technology.

In the light-capacity range, that is, of the order of up to 1 to 2 kW, fuel cells are still barely being used nowadays as an alternative to batteries or storage batteries.

This is because known fuel cell systems, which should act as battery and storage battery substitute, exhibit poorer properties than batteries and storage batteries. In particular, known fuel cell systems cannot guarantee the same running period, the same safety, comparable size and comparable weight as batteries or storage batteries.

In addition, with known systems there are no measures in place to ensure disposal of the reaction products.

Whereas with a fuel cell current strengths of clearly over $1A/cm^2$ can be achieved, as a rule electrical voltages of the order of only 0.5 to 0.7V in the charged state (1.2V in the uncharged state) can be achieved with a single fuel cell. Since most small apparatus however requires a substantially higher operating voltage, it is necessary to combine several fuel cells into one fuel cell device to be able to produce the required voltage.

It is known to combine several fuel cells into a stacked fuel cell device (fuel cell stack). These known fuel cell stacks have, however, a considerable overall height and complex fuel supply devices, generally preventing their use in small apparatus.

It is also known to arrange several fuel cells on one plane and to connect them together. For example, DE 196 36 903 discloses such a planiform configuration. The configuration illustrated in this document comprises a plurality of single cells which are each provided gas-tight in a casing. Because when such a fuel cell is manufactured the majority of single fuel cells and the corresponding majority of seals must be placed in the casing, the manufacture of such a fuel cell device is relatively expensive and thus cost-intensive.

In view of these disadvantages of the prior art the object of the present invention is to improve the known fuel cell system as well as the fuel cell devices used therein.

Brief Summary of the Invention

The abovementioned task is solved by a system for supplying a consumer with electrical power of the type mentioned at the outset, which is distinguished by a disposal device for disposing of the waste products originating from operation of the fuel cell device.

Through provision of a disposal device for the waste products of the processes running in a fuel cell the fuel side of the system can be operated without interacting with the environment at all, effectively overcoming a substantial drawback of known systems.

According to a preferred further development the disposal device can comprise a receptacle for holding waste products.

According to another advantageous further development the fuel tank device can be designed such that it serves as a receptacle. Due to these measures the structural size of the system can be reduced, which in particular enables it to be incorporated into small apparatus, such as for example portable computers, power tools, electrical domestic appliances, electrical telecommunications equipment, portable television sets, video recorders and the like.

According to another preferred further development the disposal device can have a filter device. This enables the waste products to be separated from one another. This in turn facilitates disposal of the elements arising from power generation. Furthermore, through such separation a portion of the waste products not impairing the fuel can be stored in the fuel tank device. This is incidentally one of the examples for the abovedescribed further development of the fuel tank device which also serves as a receptacle.

In accordance with an alternative further development the disposal device can also comprise an ion exchange device.

By way of advantage both the filter device and the ion exchange device can be designed to convert gases generated during operation of the fuel cell device into liquid and/or solid substances. Because of these measures only liquid and solid waste products remain after power is generated and these are substantially easier to handle than gaseous waste products.

In the system it must be ensured that the fuel cell device always has fuel available in sufficient concentration. In addition to this, the fuel must be in contact with the electrode arrangement, when positive ions pass through the electrolyte of the anode arrangement and when negative ions pass through the electrolyte of the cathode arrangement of the fuel cell device.

According to an advantageous further development of the abovedescribed system a pump device can be provided to support the fuel supply from the fuel tank device to the fuel cell device. The flow, which ensures that unused fuel is always available to the fuel cell, can be supported by such a pump device in particular with liquids. In addition, this flow also supports removal of waste products.

According to yet another further development the system can also be designed such that fuel supply is effected substantially by the pump device. In this connection the power supply can be controlled by targeted control of the pump device.

By way of advantage the pump device in the described embodiments can be designed in the form of a miniature pump. These measures serve to keep the structural size of the system to a minimum.

According to a particularly advantageous further development the pump device can be designed adjustably such that the quantity fed to the fuel cell device effects a constant

output of the fuel cell device. In this connection repeated measurements of the output of the fuel cell device serve as output quantities.

An advantage of this further development is that power supply of a consumer is possible with constant current and constant voltage, therefore with constant output.

According to another further development the abovedescribed fuel cell devices can advantageously be provided as methanol fuel cell devices. Methanol fuel cell devices are characterised in particular by the fact that liquid fuel with high-energy density is used, resulting in a compact structure of a methanol fuel cell device. In methanol fuel cells in particular a methanol-water mixture is supplied as fuel to the anode device of the fuel cell. The cathode device is supplied by an oxidant, such as air or pure oxygen, for example. Carbon dioxide occurs on the anode and water vapour occurs on the cathode as waste products of the reactions in the fuel cell.

According to an advantageous further development of the methanol fuel cell device a filter device can be used which converts carbon dioxide into a carbonate present in the solid phase. In particular, filter devices having calcium carbonate are suitable here.

As an alternative such conversion can be performed advantageously with an alkaline ion exchanger, in particular an alkaline ion exchanger based on synthetic resin, for example a hydroxide ion exchanger.

As an alternative to the methanol fuel cell device hydrogen fuel cell devices can also be utilised. In this case hydrogen is used as fuel and accordingly supplied to the anode device. The cathode device is likewise supplied with an oxidant, oxygen or air, for example. Water present in steam form occurs on the cathode as a reaction product. This can be collected in a receptacle. Alternatively, it can also be released to the atmosphere. Furthermore, in this embodiment the remaining low-oxygen air must be removed from the system. This can occur by being released to the atmosphere.

According to another preferred further development of the abovedescribed system the fuel tank device can be designed to accommodate a methanol-water mixture or hydrogen, and an oxidising agent tank device can be provided to hold an oxidising agent, for example pure oxygen or hydrogen peroxide. By way of these measures the fuel cell system can be operated as a fully closed-off system, similarly to a battery or a storage battery.

Similarly to the pump device on the fuel side a pump device can also be provided to support supply of the oxidising agent from the oxidising agent tank device to the fuel cell device.

According to another further development supply of the oxidising agent can advantageously be effected essentially by the pump device. As is the case of the pump device for fuel, effective supply of the oxidising agent to the electrode device of the fuel cell device can be guaranteed

By way of advantage the pump device can be designed in the form of a miniature pump. This again ensures minimal structural size with high functionality.

As for the pump device on the fuel side the pump device on the oxidising agent side can also be provided adjustably such that the quantity of oxidising agent supplied by the pump device of the fuel cell device ensures constant output of the fuel cell device, in such a way that the output of the fuel cell device acts as output quantity. This embodiment can be implemented alternatively for or together with regulating the pump device on the fuel side.

The abovedescribed systems can, according to another further development, include a ventilator device for supplying atmospheric oxygen from the atmosphere. An advantage of this design is that the ambient air can be used as oxidising agent. A further

advantage is that the size of the system can be smaller on account of the oxidising agent tank device being omitted. Altogether, the system can be manufactured as a smaller and more cost-effective unit. Since atmospheric oxygen is utilised, the efficiency of the system is, however, reduced when compared to a system operated on pure oxygen. The excess low-oxygen air can be released into the atmosphere in this further development

According to yet another advantageous further development of all the abovedescribed systems the overall system, therefore the fuel cell device, the fuel tank device, possibly the pump device for fuel and/or for the oxidising agent, the tank device for taking up the oxidising agent if required and the disposal device can be designed as a module which can be placed into the consumer for power supply and withdrawn from the consumer for refilling. This design enables easy replenishing of fuel and easy replacement of the system, whenever it becomes worn.

Alternatively and according to another highly advantageous further development the fuel cell device and possibly the pump device for fuel and/or for the oxidising agent of the system can be arranged on the consumer side. In this case only the fuel tank device, the tank device for holding the oxidising agent and the disposal device are designed as a module which can be placed into the consumer for power supply and withdrawn from the consumer for refilling. In this further development only the actual user components of the system can be exchanged.

An advantage of this system is that it can be replenished after the fuel is used, without the occurrence of substances which are problematical to dispose of. Even if the system has to be disposed of as such, the individual components of the system can be recycled, without the occurrence of substances which are problematical to dispose of, as is the case with recycling many types of battery or many types of storage battery.

The underlying task of the invention is also solved by a system of the type described at the outset, which is characterised in that the fuel cell device is provided on the consumer side and the fuel tank device is designed as a module, which can be placed into the consumer for power supply and withdrawn from the consumer for refilling.

These measures allow the actual consumer components of the system to be provided as exchangeable units. Because single modules can be manufactured relatively cost-effectively, these modules can be used to operate a consumer as batteries or a storage battery is used, that is, when the fuel is consumed, a fresh module can be inserted. In addition to this, since the storage capacity of a fuel cell device relative to its volume is considerably greater than that of a battery or a storage battery, the service life of the fuel cell device can be increased while the size remains the same.

This system can be developed further advantageously in a variety of ways. In particular, the advantageous embodiments can be used which have already been discussed in connection with the system, comprising a disposal device. These advantageous embodiments are itemised hereinbelow; with respect to the advantages achievable by these embodiments reference is made to the above discussion of the advantageous embodiments to avoid repetition.

According to another further development the system can be equipped with a pump device provided on the consumer side, preferably a miniature pump, to support the fuel supply from the fuel tank device to the fuel cell device.

This pump device can also be fitted in such a way that the fuel is supplied substantially by the pump device.

According to a particularly advantageous further development the pump device can be fitted adjustably, and certainly such that the quantity of fuel provided by the pump

device of the fuel cell device effects a constant output of the fuel cell device, such that the measured output of the fuel cell device serves as output quantity.

According to yet another further development a hydrogen fuel cell device can be utilised in the system as a fuel cell device.

Furthermore the system can have a pump device on the consumer side, preferably a miniature pump, to support supply of the oxidising agent to the fuel cell device.

According to a further development of the system the supply of the oxidising agent can be effected substantially by the pump device.

According to another advantageous further development the pump device can be adjusted such that the quantity of oxidising agent supplied to the fuel cell device effects a constant output of the fuel cell device, such that the output of the cell device serves as output quantity. The adjustable pump device for the oxidising agent can also be used here together with the adjustable pump device for fuel.

According to another further development the pump device can also be designed as a ventilator device for supplying ambient oxygen from the atmosphere.

The third aspect of the task underlying the invention, namely improvement of the fuel cell device, is solved by a fuel cell device of the type initially described, which is characterised in that each fuel cell device exhibits a single, essentially flat electrolyte device, such that each anode device and its corresponding cathode device are placed on opposite sides of the electrolyte device.

Hereby it is no longer necessary compared to the prior art to place every single fuel cell made up of anode, electrolyte and cathode gas-tight into a casing. The manufacturing

process and thus manufacturing costs of the fuel cell device can thus be simplified or reduced substantially.

Alternatively the known fuel cell device is improved by the fact that at least two fuel cell devices are provided with a plurality of anode devices, a plurality of cathode devices, where each cathode device is assigned a corresponding anode device, and a plurality of electrolyte devices, such that an anode device and a corresponding cathode device are arranged respectively on opposite sides of a corresponding electrolyte device and together form a single cell, where all single cells of a fuel cell device are arranged in one plane, and the at least two fuel cell devices are arranged above one another.

In particular, the voltage achievable with the known fuel cell device can hereby be increased as such by optimising dimensioning, that is, reduction in size, of the fuel cell device.

According to an advantageous further development of these alternatives corresponding anode devices and cathode devices can exhibit the same size and form. This guarantees effective generation of power with minimal structural size.

According to another advantageous further development of the abovedescribed fuel cell devices ion-permeable, preferably proton-permeable current conductors, which are connected together by a switching device, can be provided between the electrolyte device(s) and the anode devices and/or between the electrolyte device(s) and the cathode devices.

As an alternative to this fuel-permeable or oxidising agent-permeable current conductors can also be used which are provided on the anode devices and/or the cathode devices, in such a way that the current conductors are connected together by a connection device.

According to a further alternative fuel-permeable or oxidising agent-permeable current conductors, which are connected to one another by means of a connection device, can be provided in the anode devices and/or in the cathode devices.

The above three alternatives for arranging the current conductors relative to the anode devices or the cathode devices can each be inserted singly, that is, for all electrodes of the fuel cell device, or they may also be combined in any other way.

In this connection each current conductor can preferably be designed as a braid or a thin perforated plate or a perforated film. Firstly, good contact is ensured between current conductor and electrode; secondly, the fuel and the oxidising agent can make contact with the electrode devices without difficulty.

Each current conductor can comprise nickel, platinum, gold, and/or stainless steel. The durability of the current conductors can be increased considerably by use of these materials.

According to an advantageous further development of the current conductor the latter can be approximately the same size as the assigned anode device or the assigned cathode device. In this design maximum possible contact between current conductor and electrode device is guaranteed and the resistance between current conductor and electrode device is thereby minimised.

According to a particularly advantageous further development the connection device can include strip conductors. This measure can produce particularly simple connection of the individual fuel cells. In particular, an integrated circuit can be realised hereby.

These strip conductors can be attached to the electrolyte device, for example.

In particular, with respect to current conductors which are also attached to the electrolyte device (or between electrolyte device and anode or cathode device), the advantage of relatively simple manufacture arises. Therefore in one operating step the entire current conductor /strip conductor sample can be designed on the electrolyte device, for example using processes such as masking, photolithography, etching, layering and the like known from semi-conductor technology.

According to an advantageous further development the connection device can exhibit a strip conductor for at least one anode device and a strip conductor for at least one cathode device, such that the strip conductors are connected at the edge of the electrolyte device to a connector.

Moreover, the connection device for at least one anode device and at least one cathode device can have a strip conductor which is guided from the anode side to the cathode side on the electrolyte device. The individual cells can accordingly be connected in series.

Any arbitrary connection of the individual fuel cells can be realised by random combination of both these alternatives. By way of example, all fuel cells can be connected to one another in series by the second alternative and the tap, therefore the strip conductor which is attached at the edge of the electrolyte device to the connector, can be provided on the first and last fuel cell of this series. On the other hand each fuel cell can be tapped per se by the first alternative and connected externally in any manner. Both these alternatives and a combination of both alternatives open up a large number of options for adapting a fuel cell device to the various current and voltage requirements of a consumer.

According to an advantageous further development a switch device, which is designed to modify the connection device of the anode devices and the cathode devices of at least one or at least two fuel cell devices, can be provided. Optimum adaptation of the

electrical power generated by the fuel cell device to the requirements of a consumer is enables thereby. Moreover, this adaptation can also be easily altered and thus adapted to the requirements of one or various consumers.

By way of advantage the switch device of the fuel cell device can comprise a connection device which can be connected to the connection device at the edge of the electrolyte device. This connection device may comprise a plug board for example.

According to a further development of the abovementioned fuel cell devices the electrolyte device can be provided in the form of a proton-conducting electrolyte film. Such a film can be worked and processed relatively easily, keeping manufacturing costs of the fuel cell device to a minimum.

The fuel cell device can, according to an advantageous further development, comprise methanol fuel cell devices. In this case an electrolyte device including nafion is preferably suitable.

The advantages already discussed in connection with the embodiments of the systems of a methanol fuel cell device also apply here.

According to an alternative further development the fuel cell device can also have hydrogen fuel cell devices; in this case electrolyte devices including nafion are also suitable.

Here too the advantages of a hydrogen-fuel cell device already discussed in connection with the embodiments of the systems apply.

The abovedescribed fuel cell devices can preferably be manufactured by semi-conductor processes, electroplating processes or other known surface-coating processes.

According to a particularly advantageous further development of all abovedescribed fuel cell devices these can have at least two fuel cell devices, such that each two adjacent fuel cell devices are connected to one another by an electrically insulating connection device, and each two adjacent fuel cell devices are arranged such that the anode devices of the first of these fuel cell devices face the anode devices of the second of these fuel cell devices or the cathode devices of the first of these fuel cell devices face the cathode devices of the second of these fuel cell devices, and each connection device has a supply distribution structure for the fuel to be supplied to the anode devices or the oxidising agent to be supplied to the cathode devices.

In this way n fuel cell devices can be interconnected. For this n – 1 of the abovedescribed connection devices are required. For the first and last fuel cell device elements can be provided which exhibit supply ducts which are open on one side of the element only. Alternatively, the abovedescribed connection devices can be used, where the supply distribution structure is to be connected to one side of the connection devices to prevent the fuel or oxidising agent from escaping.

By means of this further development stacks of fuel cell devices can be formed and any voltages corresponding to the respective requirements can be created thereby. In particular, fuel cell devices can be created by these embodiments, whose output compared to batteries and storage batteries can be lowered considerably at the same voltage. By means of this so-called monopolar connection of the individual fuel cell devices minimal structural sizes can be realised, since only one supply distribution structure is required for every two cells. Fuel cell devices whose size corresponds to conventional batteries and storage batteries can thus be realised.

Alternatively to this and according to another further development the fuel cell device can also have a stack shape with at least two fuel cell devices, in which each two adjacent fuel cell devices are interconnected by an electrically insulating connection

device, such that each cathode side of a first of the two fuel cell devices of the anode device faces the second of the two fuel cell devices, and each connection device has a first supply distribution structure for the fuel to be supplied to the anode devices and a second supply distribution structure for the oxidising agent to be supplied to the cathode devices.

This alternative, with which any voltage can likewise be produced, can be used in particular whenever the overall height is less critical. Incidentally, the advantages, which have already been discussed in connection with the monopolar connection of the fuel cell devices, also emerge for such a further development with these connection devices.

According to an advantageous further development of the above latter alternatives each connection device can have conducting elements which are arranged such that it electrically conductively connects each anode device of a first of the two adjacent fuel cell devices with the cathode device of the second of the two adjacent fuel cell devices facing it and corresponding to it.

This further development enables different, respectively superposed cells of different fuel cell devices to be connected to one another in a stack. In this connection a bipolar connection is realised in each stack for superposed fuel cells of different fuel cell devices. The different stacks made up in this way need to be connected to one another by the uppermost and lowest cell of the stack only. Thereby the connection expense in the fuel cell device can be reduced.

The abovedescribed stacked fuel cell devices can, as can the fuel cell devices having one fuel cell device only, have a connection device in the form of strip conductors according to an advantageous further development.

In this connection the strip conductors can be provided advantageously on or in the connection device. The fuel cell device can be consequently manufactured in

particularly simple fashion. In particular, fuel cell devices and the connection devices can be formed by means of processes known from semi-conductor technology. Accordingly, the fuel cell devices and the connection devices merely need to be combined and the fuel cell devices connected.

According to a preferred further development a fuel cell device can be provided, in which the connection device includes a strip conductor for at least one anode device and a strip conductor for at least one cathode device, where the strip conductors are connected at the edge of the connection device to a connector.

Apart from connection of the individual fuel cells random connecting of the individual fuel cell devices is also possible. Here the individual cells can be connected in different groups in different fuel cell devices at random, by means of which a plurality of possible currents and voltages can be obtained. Such fuel cell devices can therefore be flexibly used for a wide variety of applications.

According to an advantageous further development of this embodiment the abovedescribed fuel cell devices can be provided in a casing, and the connectors can extend through a wall of this casing. By means of this particular measure the entire fuel cell device can be connected to a corresponding connector and/or switchgear.

Low-temperature fuel cell devices are particularly suitable for use in small apparatus, such as portable computers and the like,.

The abovedescribed fuel cell devices are particularly suitable for outputting less than approximately one kW.

The discussed systems and the fuel cell devices utilised therein are optimised for the low-output range, in particular with respect to their power output and size, but can also be used with corresponding dimensioning in other output ranges.

Although not mentioned explicitly, a plurality of the abovedescribed features can be combined together, so that the advantages described for the individual features can be achieved in combination. In particular, all described fuel cell devices are suited for use in the systems described at the outset.

Brief Description of the Drawings

Preferred embodiments of the present invention are described hereinbelow with reference to the accompanying diagram, in which:

Figure 1 shows a first embodiment of the system for supplying an electrical consumer with power according to the present invention,

Figure 2 shows a second embodiment of the system for supplying an electrical consumer with power according to the present invention,

Figure 3 shows a third embodiment des system for supplying an electrical consumer with power according to the present invention,

Figure 4 shows a fourth embodiment of the system for supplying an electrical consumer with power according to the present invention,

Figure 5 shows a first embodiment of a fuel cell device according to the present invention, in particular for use in one of the systems of Figures 1 to 4,

Figure 6 shows a second embodiment of a fuel cell device according to the present invention, in particular for use in one of the systems of Figures 1 to 4,

Figure 7 shows a third embodiment of a fuel cell device according to the present invention, in particular for use in one of the systems of Figures 1 to 4,

Figure 8 shows a fourth embodiment of a fuel cell device according to the present invention, in particular for use in one of the systems of Figures 1 to 4,

Figure 9 shows a fifth embodiment of a fuel cell device according to the present invention, in particular for use in one of the systems of Figures 1 to 4,

Figure 10 shows a sixth embodiment of a fuel cell device according to the present invention, in particular for use in one of the systems of Figures 1 to 4, and

Figure 11 shows a detailed view of a current conductor in a fuel cell device according to the present invention.

Detailed Description of the Invention

Figure 1 illustrates a first embodiment of a system 10 according to the present invention for supplying an electrical consumer with power. The illustration of the system is, in particular with respect to the illustrated ratios of dimensions, to be understood diagrammatically only.

The system comprises a fuel cell device 11 for generating the electrical power, a fuel tank device 12 for holding the fuel and a disposal device 13 for disposing of the waste products resulting from operation of the fuel cell.

The fuel cell device 11 comprises an anode area 11a, an electrolyte device 11c which is permeable to ions, in particular protons and impermeable to electrons, and a cathode area 11b. The anode area and the cathode area can be designed in particular by a

plurality of anodes or cathodes, as is explained in detail in connection with the description of Figures 5 to 9.

Figure 1 illustrates a system 10, in which fuel is supplied to the anode area 11a, which is not fully converted, that is, which does not reach the cathode area 11b fully after conversion into ions via the electrolyte device 11c. Accordingly, waste substances occur from operation of the fuel cell in the anode area 11a, which are disposed of by the disposal device 13 which is designed as a filter device in the present embodiment.

The fuel is supplied from the fuel tank device 12 to the fuel cell device 11 by a pump device 14.

An oxidising agent is supplied to the cathode area 11b in the illustrated embodiment. When the fuel cell is operating the oxidising agent reacts with the fuel constituents which have reached the cathode area via the electrolyte device 11c. The illustrated embodiment is particularly suitable, if innoxious substances occur in the cathode area, which can be released to the atmospheric air without risk.

An example for a fuel cell device of the previously described type is a methanol fuel cell device. A methanol-water mixture is used here as fuel. Oxygen, for example in the form of atmospheric air, is supplied as oxidising agent to the cathode area. A ventilator 16, or alternatively a pump device, is used for this purpose.

Conditional on a catalyst the methanol reacts in the methanol-water mixture in the anode area 11a to protons, carbon dioxide and electrons. The protons migrate through the proton-permeable membrane 11c, which can be formed from nafion for example, into the cathode area 11b where they react with oxygen ions from the atmospheric air and which have been ionised by a catalyst. Water vapour, which is released along with the unused portion of the air into the atmosphere occurs here as waste product.

The electrons resulting from reaction are conveyed from the anode area to the cathode area in the form of electrical current.

The carbon dioxide originating in the anode area is flushed along with the water from the anode area into the filter device 13. This process, as for the supply of fuel to the fuel cell device, is supported by the pump device 14.

In the filter device 13 the carbon dioxide is converted into carbonate. In the illustrated embodiment a calcium dioxide filter is used, in which the carbon dioxide is converted into calcium carbonate with the formation of water.

An ion exchanger, in particular an alkaline ion exchange device based on synthetic resin, can be used as an alternative to the filter device. A synthetic resin matrix, on which hydroxide ions are stored, is suitable for this for example. In such an ion exchange device the carbon dioxide is converted into calcium carbonate, which accumulates on the matrix, with the formation of water.

The water resulting from filtering is supplied back to the fuel tank device 12 along with the unused portion of the methanol-water mixture.

In continuous operation the methanol is caused to react in the methanol-water mixture, which is why the concentration of the methanol in the methanol-water mixture is reduced to a value at which the abovedescribed reaction can no longer be carried out efficiently. The filter device is added by disposal of the carbon dioxide resulting from reaction. The available fuel and the filter device are effectively such that the concentration value is reached and the filter device is added at the same time.

According to the embodiment in Figure 1 the fuel tank device 12 and the filter device 13 are designed as a module, while the fuel cell device, the pump devices, the ventilator device and the supply ducts and outlets not described in greater detail are provided on

the consumer side. This module can, as indicated by the arrow in Figure 1, be withdrawn from the consumer and reprocessed. In addition to this the fuel tank device is filled with fuel and the filter device or the ion exchange device is brought to its original state by chemical or physical means or completely exchanged.

In the illustrated embodiment some 5ml methanol are required for a consumer to operate for 10 hours with 20 Watt. At a concentration of 4 vol.% methanol in the methanol-water mixture approximately 125ml fuel mixture are required accordingly.

Figure 2 illustrates a second embodiment of the system 20 according to the present invention for supplying an electrical consumer with power. Depiction of the system, in particular with respect to the illustrated ratios of size, is to be understood schematically only. In order to avoid repetition hereinbelow reference is made only to the differences to the system illustrated in Figure 1 and with respect to the other components reference is made to the corresponding description of Figure 1. The reference numerals, with which corresponding components are designated, hereby differ by the first digit respectively.

An essential difference between the system 20 and the system 10 is that the system 20 is provided for fuels which are fully combusted. Accordingly, no waste substances occur in system 20 on the anode side. The anode area 21b consequently has no discharge and no disposal device.

The fuel cell device illustrated in Figure 2 may be realised in the form of a hydrogen fuel cell device. In such a device hydrogen, which is fully converted into protons by means of a catalyst, is supplied to the anode. These protons pass through the proton-permeable membrane to the cathode area. In the cathode area oxygen is converted from the atmospheric air into oxygen ions, likewise by means of a catalyst. The oxygen ions finally react with the protons to water vapour. The electrons resulting from these reactions are taken off as current.

The module removable from the system is formed in the embodiment illustrated in Figure 2 by the fuel tank device 22.

Figure 3 illustrates a third embodiment of a system 30 according to the present invention for supplying an electrical consumer with power. Depiction of the system, in particular with respect to the illustrated ratios of size, is to be understood schematically only. The system 30 is similar to the system 10 illustrated in Figure 1. Therefore, to avoid repetition hereinbelow reference is made only to the differences to the system illustrated in Figure 1 and with respect to the other components reference is made to the corresponding description of Figure 1. The reference numerals, with which corresponding components are designated, hereby differ by the first digit respectively.

The system according to Figure 3 differs from the system according to Figure 1 by the fact that the oxidising agent is not removed from the atmospheric air and the waste products on the cathode side are not released to the atmosphere. This system accordingly is particularly suitable for fuels whose conversion produces environmentally-unfriendly waste products.

The oxidising agent is made available in an oxidising agent tank device 35, from where it makes its way into the cathode area 31a of the fuel cell device 31 by way of a pump device 36. The waste products of this process are guided to a disposal device 33 via an outlet pipe. The disposal device 33 comprises an ion exchange device 33-1 and a receptacle 33-2.

The pump device 36 is designed adjustably in this embodiment, and certainly so that the quantity of fuel supplied to the fuel cell device effects a constant output of the fuel cell device 31. The output released by the fuel cell device 31 is used as output quantity. Measurements of the output of the fuel cell device are made continuously by a meter

(not illustrated) and in the pump rate is increased or decreased dependent on the measured output.

A methanol fuel cell device can again be employed as an example of such a fuel cell device.

Pure oxygen is supplied from the oxidising agent tank device 35 to the cathode area as oxidising agent by means of a pump device 36, designed in the form of a micro pump. Accordingly, water vapour is the only waste product occurring on the cathode side. The resulting water vapour is conveyed to the receptacle 33-2 via a pipe and stored there. On the anode side carbon dioxide forms as waste product in system 30, and is converted into calcium carbonate in an ion exchange device 33-1, as described hereinabove, with formation of water. The resulting water is finally fed to the fuel tank device 32.

An advantage of system 30 as compared to system 10 is that no waste products are released to the atmosphere and that more efficient generation of power can occur by the use of pure oxygen.

In the embodiment illustrated in Figure 3 the module which can be removed from the system is formed by the fuel tank device 32, the ion exchange device 33-1, the receptacle 33-2 and the oxidising agent tank device 35.

Figure 4 illustrates a fourth embodiment of a system 40 according to the present invention for supplying an electrical consumer with power. Depiction of the system, in particular with respect to the illustrated ratios of size, is to be understood schematically only. The system 40 is similar to the systems 20 and 30 illustrated in Figure 2 and in Figure 3. In order to avoid repetition therefore, hereinbelow reference is made only to the differences to the systems illustrated in Figures 2 and 3 and with respect to the other components reference is made to the corresponding description of Figures 2 and

3. The reference numerals, with which corresponding components are designated, hereby differ by the first digit respectively.

As with system 20 in Figure 2, system 40 is operated with a fuel which is fully converted on the anode side. There are accordingly no waste products on the anode side, and as a result thereof neither a discharge nor a disposal device is provided on the anode side. And there are no differences apparent between system 30 and system 40.

Hydrogen in particular is suitable for operating system 40, as for the operation of system 20 in Figure 2. Hydrogen is converted into protons on the anode side without waste products. These protons migrate via the electrolyte device and react on the cathode side, to which pure oxygen is supplied from the oxidising agent tank device 45, with catalysed oxygen ions into water vapour. This water vapour can be condensed into water by means of a capacitor and then stored in the receptacle 43.

The module which can be removed from the system is formed in the embodiment illustrated in Figure 4 by the fuel tank device 42, the receptacle 43 and the oxidising agent tank device 45.

The illustrated embodiments of the systems are to be understood by way of example only and not as restrictive. By way of example a plurality of fuels, gaseous or liquid, and a plurality of oxidising agents, can also be used in the gaseous or liquid state.

The only stipulation is that the fuel in question can be dissipated by means of a catalyst device into ions which can migrate via the electrolyte device, and react on the cathode side with ions which result from conversion of an oxidising agent into ions.

In the embodiments illustrated in Figures 1 to 4 proton-permeable electrolytes were used. Depending on the fuel being used, however, other electrolyte devices can also be used which are permeable for positive or negative ions.

It should be noted that when electrolyte devices which are permeable for negative ions are used the fuel is to be returned to the cathode. With fuel which is fully converted all waste products accordingly accumulate on the anode side.

Moreover, all embodiments of the anode devices, the cathode devices, the electrolyte devices, the catalysts, and various materials for the fuel cell devices known to the expert in the domain of fuel cells can be used in the abovedescribed embodiments.

Embodiments of fuel cell devices according to the present invention are explained hereinbelow. These fuel cell devices are particularly suited to the abovedescribed systems, but can also be utilised for a wide range of applications

Figure 5 illustrates a first embodiment of a fuel cell device according to the present invention schematically in section. Depiction of the fuel cell device is to be understood schematically only, in particular with respect to the illustrated ratios in size.

Figure 5 in particular shows a fuel cell device 50 for use in a fuel cell device according to the present invention .

The fuel cell device 50 comprises an electrolyte device 55 in the form of an ion-conducting membrane, on which three anode devices 51 and three cathode devices 52 are provided.

The anode devices 51 and the cathode devices 52 can be connected to the membrane using methods known in the domain of fuel cell technology. Alternatively, the anode devices 51 and the cathode devices 52 can also be applied to the membrane 55 using processes known from semi-conductor technology, electroplating processes or other surface-coating processes.

In this configuration a cathode device 52 is assigned to each anode device 51. The anode devices 51 and the cathode devices 52 are the same shape and size. As a result, the same voltage and the same current are delivered by each anode/cathode device. The anode devices 51 and the cathode devices 52 can also be different in size and shape, though this leads to the fact that firstly the individual devices no longer give out a defined current, and secondly that the current yield is reduced in the case of predetermined structural size, as compared to identical form and size.

Strip conductors 54, which serve to connect the anode devices 51 and the cathode devices 52, are also applied to the membrane 55. This can occur by way of processes known from semi-conductor technology, electroplating processes or other surface-coating processes, for example.

Figure 5 in particular shows an anode device connection 56a on the edge of the membrane 55 and a cathode device connection 56b.

In addition, the three individual cells are connected in series in the illustrated embodiment. This is realised by two strip conductors 56c, which are each guided from the anode side to the cathode side via the membrane. Methods known from semi-conductor technology can also be employed to form such strip conductors.

Furthermore, the embodiment illustrated in Figure 5 comprises current conductors 56d each of which is provided between the electrolyte device and the anode devices 51 or the cathode devices 52. The current conductors have openings for ensuring transport of ions through the electrolyte device. To increase the service life of same the current conductors 56d comprise an inert material, such as for example nickel, gold, platinum, stainless steel or alloys of the same.

The overall strip conductor/current conductor structure can be designed in the embodiment illustrated in Figure 5 in a single step, for example employing procedures

known from semi-conductor technology, such as masking, photolithography, etching, coating and the like. Alternatively, electroplating coating processes or other surface-coating processes may also be employed.

The fuel cell device illustrated in Figure 5 further comprises a supply device for the fuel and the oxidising agent (not shown). In this connection the fuel is supplied to the anode devices; the oxidising agent is fed to the cathode devices.

It must be ensured that fuel and oxidising agent do not mix in order to guarantee the operating safety and functionality of the fuel cell. This is guaranteed in the illustrated embodiment by the fact that the membrane 55 used is impermeable for both the fuel and the oxidising agent. With respect to the prior art it is no longer necessary for the individual cells to be sealed off from one another. Rather the fuel on the one hand and the oxidising agent on the other hand can be guided along the membrane. In particular, with use of strip conductors 56c, which are guided from the anode side to the cathode side, care should be taken that no leakages occur during operation to hinder the functioning of the fuel cell devices.

As explained in detail with reference to Figures 7 to 9, several of the illustrated fuel cell devices can be combined into one fuel cell device, in this instance designated as a fuel cell stack.

Figure 6 illustrates a second embodiment of a fuel cell device according to the present invention in a diagrammatic plan view. In particular, Figure 6 shows a fuel cell device 60 for use in a fuel cell device according to the present invention. The fuel cell device 60 is similar to the fuel cell device 50 illustrated in Figure 5. Therefore in order to avoid repetition hereinbelow reference is made only to the differences to the fuel cell device illustrated in Figure 5 and with respect to the other components reference is made to the corresponding description of Figure 5.

The fuel cell device 60 comprises nine anode devices 61 which are arranged on a continuous membrane 65. In addition, nine cathode devices are provided which are each below the anode devices 61 in the plane of projection. Current conductor devices in the form of a perforated structure are provided on the electrolyte device 65 also under the anode devices 61 and thus are not visible in the plan view.

The essential difference between the embodiments illustrated in Figure 5 and in Figure 6 is in the switching device. In the fuel cell device 60 only strip conductors 66a and 66b, which are guided to the edge of the membrane 65, are used. The nine strip conductors 66a are connected to the anode devices 61. The nine strip conductors 66b (of which three only are shown in dashed lines, as they are on the underside of the membrane) are connected to the cathode devices.

On the edge of the membrane all strip conductors are connected to connectors in the form of contact pins 67a and 67b.

These contact pins 67a and 67b are arranged such that they can be engaged with a plug board of a switch device 69.

The switch device 69 is designed such that the anode devices 61 and the cathode devices 62 can be connected in various ways known to the expert in parallel (for addition of currents) and in series (for addition of voltages). A plurality of different voltages U and currents I can be made available at the outlet of the switch device 69.

Apart from the toggling illustrated in Figure 5 and Figure 6 any combination of the illustrated embodiments can be implemented, according to application. By way of example it is possible to firmly connect an array of the membrane/electron devices toggled with one another in series in Figure 6 respectively and to variably interconnect the rows by the switch device.

In connection with the embodiments of Figures 5 and 6 it is pointed out that the use of strip conductors is to be understood by way of example only and not restrictively. Any other connection devices may be employed; for example the anode devices and the cathode devices can also be connected by wires.

Figure 7 diagrammatically illustrates a third embodiment of a fuel cell device according to the present invention. In this figure also the size ratios are not shown realistically for the sake of clearer representation. In particular, Figure 7 shows a fuel cell device 70 which comprises three fuel cell devices 70a, 70b and 70c, similar to those described in Figure 5 and Figure 6.

Each of the fuel cell devices 70a, 70b and 70c has a plurality of anode devices 71 and a plurality of cathode devices 72 which are arranged on a membrane 75. As indicated in the fuel cell device 70a, the individual cells of the fuel cell devices 70a, 70b and 70c are connected together in series by strip conductors, resulting in an increase in voltage.

The fuel cell devices 70a, 70b and 70c are electrically connected in series according to Figure 7.

In the fuel cell device 70 the fuel cell devices 70a and 70b, as well as 70b and 70c are interconnected by means of connection devices 77a and 77b. In this respect each two fuel cell devices 70a, 70b and 70c are arranged such that the anode sides of the devices 70a and 70b lie opposite the cathode sides of the devices 70b and 70c.

The connection devices 77a and 77b each comprise an insulation material, so that the anode devices 71 and the cathode devices 72 of two adjacent fuel cell devices are electrically insulated from one another.

The connection devices 77a and 77b each comprise a distribution structure 79a for supplying fuel B to the anode devices and a distribution structure 79b for supplying

oxidising agent O to the cathode devices. The distribution structure can be designed arbitrarily. By way of example it can be present in the form of a channel structure or a porous structure. Furthermore, fuel and oxidising agent can be supplied parallel to one another (see Figure 7); it is also possible to supply fuel and oxidising agent alternatingly. Supply of fuel B and oxidising agent O is indicated in Figure 7 by arrows.

A closing plate 78a and 78b is provided respectively on the outsides of the fuel cell devices. As evident from Figure 7 each closing plate has only one distribution structure.

The distribution structures illustrated in Figure 7 are connected to a fuel supply and an oxidising agent feed, as shown for example in connection with the embodiments described in Figures 1 to 4.

According to Figure 7 the strip conductors are applied to connect the electrodes to the membrane 75. Alternatively the strip conductors can also be applied to the connection devices 77a and 77b and/or the closing plates 78a and 78b. The previously mentioned methods can be used for this purpose.

Figure 8 diagrammatically illustrates a fourth embodiment of a fuel cell device 80 according to the present invention in section. The fuel cell device 80 is similar to the fuel cell device 70 illustrated in Figure 7. Therefore in order to avoid repetition hereinbelow reference is made only to the differences to the fuel cell device 70 illustrated in Figure 7 and with respect to the other components reference is made to the corresponding description of Figure 7.

The fuel cell devices 80a, 80b and 80c are arranged such that each of the cathode sides or the anode sides of two adjacent fuel cell devices lies opposite each another. As in the embodiment in Figure 7 the fuel cell devices 80a and 80b or 80b and 80c are also interconnected by connection devices 88a and 88b.

According to the illustrated configuration the fuel cell devices 80a, 80b and 80c are connected to one another in series (as shown in Figure 8).

As compared to the configuration in Figure 7 it is sufficient in configuration 80 that the connection devices 88a and 88b each have only one distribution structure for supplying the oxidising agent or the fuel.

An added difference between the fuel cell devices 70 and 80 consists of the fact that in the device 80 fuel-permeable or oxdant-permeable current conductors 83 in the form of a braid or a perforated plate are provided on the anode devices 81 or the cathode devices 82. These current conductors are connected to strip conductors which are applied to the membrane 85 or to the connection device 88a or 88b. Alternatively, the current conductors can also be connected by wires for switching between electrodes. Both the strip conductors and the wires can be guided by the connection device 88b. This is illustrated by way of example in Figure 8 for the lowest anode connection 81a.

Figure 9 diagrammatically illustrates a fifth embodiment of a fuel cell device 90 according to the present invention in section. The fuel cell device 90 corresponds to the fuel cell device 80 illustrated in Figure 8. The sole difference between both devices is that the device 90 has a number of electrolyte devices 95 corresponding to the number of devices 91 or cathode devices 92. Because in this embodiment there is no separation between fuel and oxidising agent due to a continuous membrane, with the configuration of single cells it must be ensured that separating the fuel side and oxidising agent side of a fuel cell device is otherwise guaranteed. As a result sealing devices 99 are provided in the embodiment illustrated in Figure 9.

Incidentally, to avoid repetitions with respect to the remaining components reference is made to the corresponding description of Figure 8.

Figure 10 diagrammatically illustrates a sixth embodiment of a fuel cell device 100 according to the present invention in section. The fuel cell device 100 corresponds to the fuel cell device 70 illustrated in Figure 7. It comprises in particular three fuel cell devices which each comprise anode devices 101 (101-1, 101-2), cathode devices 102 (102-1, 102-2), and an electrolyte device 105 (105-1, 105-2).

The most important difference between both devices is that the connection device 107 has conducting elements 110a and 110b. Each connection device 107 is accordingly divided into conducting areas 110a and 110b (horizontal hatching in Figure 10) and non-conducting areas (vertical hatching in Figure 10).

The conducting elements 110a and 110b are arranged such here that they electrically conductively connect each anode device 101-1 of a first of two adjacent fuel cell devices 101-1, 105-1, 102-1 to the cathode device 102-2 facing it and corresponding to it of a second of two adjacent fuel cell devices 101-2, 105-2, 102-2.

This enables different, respectively superposed cells of different fuel cell devices to be connected to one another in a stack. In this connection a bipolar connection is made in each stack for superposed fuel cells of different fuel cell devices. The different stacks made up in this way need to be connected to one another by the uppermost and lowest cell of the stack only. Thereby the connection expense in the fuel cell device can be reduced.

The abovedescribed configuration also results in a distribution structure modified in comparison to Figure 7. In particular, the anode devices 101 and the cathode devices 102 are circulated laterally by the fuel or the oxidising agent in the embodiment illustrated in Figure 10.

Incidentally, to avoid repetitions with respect to the remaining components reference is made to the corresponding description of Figure 7.

Figure 11 illustrates an alternative embodiment of a current conductor according to the present invention in section. Figure 11 shows a fuel cell which is composed of an anode device 111, a cathode device 112 and an electrolyte device. Figure 11 also depicts a current conductor which is provided in the anode device 111 or in the cathode device 112.

The current conductor 116 preferably comprises a perforated film which ensures passage for ions, as well as the fuel and the oxidising agent. With respect to the material to be used the same applies that has already been carried out with the current conductors described in Figure 5 and in Figure 8.

The embodiments described in connection with Figures 1 to 11 are to be understood by way of example and not restrictively.

In particular, the number of fuel cell devices, the number of cells per fuel cell device, the permeable membrane or the single membranes, the respectively illustrated connections (including use of switch device), the different connection devices (monopolar plate, bipolar plate), are independent features and can be combined with one another at random.

We claim:

1. A system for supplying a consumer with electrical power, comprising: a fuel cell device for generating electrical power, and a fuel tank device for holding fuel to be supplied to the fuel cell device, characterised by a disposal device for disposing of waste products resulting from operation of the fuel cell device.

2. A system as claimed in Claim 1, in which the disposal device has a receptacle for holding the waste products.

3. A system as claimed in Claim 2, in which the fuel tank device is designed such that it serves as the receptacle.

4. A system as claimed in Claim 1, in which the disposal device has a filter device.

5. A system as claimed in Claim 1, in which the disposal device has an ion exchange device.

6. A system as claimed in Claim 4, in which the disposal device is designed to convert gases resulting from operation of the fuel cell device into at least one of liquid and solid substances.

7. A system as claimed in Claim 1, further comprising a pump device, for supporting a fuel supply from the fuel tank device to the fuel cell device.

8. A system as claimed in Claim 7, in which the fuel is supplied essentially by the pump device.

9. A system as claimed in Claim 7, in which the pump device can be adjusted such that the quantity of fuel supplied by the pump device of the fuel cell device effects a constant output of the fuel cell device, such that the output of the fuel cell device serves as output quantity.

10. A system as claimed in Claim 1, in which the fuel cell device is a methanol fuel cell device.

11. A system as claimed in Claim 10, in which the disposal device includes a filter device that converts carbon dioxide to a carbonate.

12. A system as claimed in Claim 10, in which the disposal device includes an ion exchange device has an alkaline exchanger based on synthetic resin.

13. A system as claimed in Claim 1, in which the fuel cell device is a hydrogen fuel cell device.

14. A system as claimed in Claim 10, in which the fuel tank device is designed to hold a methanol-water mixture, further comprising an oxidising agent tank device to hold an oxidising agent.

15. A system as claimed in Claim 14, further comprising a pump device, for supporting the supply of oxidising agent to the fuel cell device.

16. A system as claimed in Claim 15, in which the oxidising agent is essentially supplied by the pump device.

17. A system as claimed in Claim 15, in which the pump device can be adjusted such that the quantity of oxidising agent supplied by the pump device of the fuel cell

device effects a constant output of the fuel cell device, such that the output of the fuel cell device serves as an output quantity.

18. A system as claimed in Claim 10, further comprising a pump device, for supporting the supply of oxidising agent to the fuel cell device, in which the pump device is designed as a ventilator device for supplying atmospheric air from the environment.

19. A system as claimed in Claim 1, in which the fuel cell device, the fuel tank device, and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

20. A system as claimed in Claim 1, in which the fuel cell device is arranged on the consumer side, and the fuel tank device and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

21. A system for supplying a consumer with electrical power, comprising:
a fuel cell device for generating electrical power, and
a fuel tank device for housing the fuel to be supplied to the fuel cell device,
characterised in that the fuel cell device is provided on the consumer and the fuel tank device is a module that can be inserted into the consumer to supply power and removed from the consumer.

22. A system as claimed in Claim 21, further comprising a pump device provided on the consumer side, for supporting a fuel supply from the fuel tank device to the fuel cell device.

23. A system as claimed in Claim 22, in which the fuel is supplied essentially by the pump device.

24. A system as claimed in Claim 22, in which the pump device can be adjusted such that a quantity of fuel supplied by the pump device of the fuel cell device effects a constant output of the fuel cell device, such that the output of the fuel cell device serves as output quantity.

25. A system as claimed in Claim 21, in which the fuel cell device is designed as a hydrogen fuel cell device.

26. A system as claimed in Claim 21, further comprising a pump device provided on the consumer side, for supporting a supply of the oxidising agent to the fuel cell device.

27. A system as claimed in Claim 26, in which the supply of the oxidising agent is essentially supplied by the pump device.

28. A system as claimed in Claim 26, in which the pump device can be adjusted such that the quantity of oxidising agent supplied by the pump device of the fuel cell device effects a constant output of the fuel cell device, such that the output of the fuel cell device serves as an output quantity.

29. A system as claimed in Claim 26, in which the pump device is designed as a ventilator device for supplying atmospheric air from the environment.

30. A fuel cell device, comprising:
a plurality of anode devices, and
a plurality of cathode devices, such that a corresponding one of said plurality of anode devices is associated with each said cathode device,

characterised in that the fuel cell device includes a substantially flat electrolyte device, such that each said anode device and its corresponding cathode device are arranged on opposite sides of the electrolyte device.

31. A fuel cell device apparatus comprising at least two fuel cell devices, wherein each fuel cell device comprises:

a plurality of anode devices,

a plurality of cathode devices, such that a corresponding one of said plurality of anode devices is associated with each said cathode device, and

a plurality of electrolyte devices, such that

each said anode device and said corresponding cathode device are arranged on opposite sides of a corresponding electrolyte device and together form a single cell, and

all said single cells of each of the fuel cell devices are arranged on one plane.

32. A fuel cell device as claimed in Claim 30, in which the anode devices are substantially the same size and shape as the corresponding cathode devices.

33. A fuel cell device as claimed in Claim 30, further comprising ion-permeable current conductors, interconnected by a connection device and disposed between at least one of the electrolyte device and the anode devices, and the electrolyte device and the cathode devices.

34. A fuel cell device as claimed in Claim 30, further comprising one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed on at least one of the anode devices and the cathode devices.

35. A fuel cell device as claimed in Claim 30, further comprising one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed in at least one of the anode devices and the cathode devices.

36. A fuel cell device as claimed in Claim 80, in which each current conductor has a braid or a perforated film.

37. A fuel cell device as claimed in Claim 80, in which each current conductor comprises at least one of nickel, gold, platinum, and stainless steel.

38. A fuel cell device as claimed in Claim 80, in which each current conductor is substantially the same size as one of the respective anode device and the respective cathode device.

39. A fuel cell device as claimed in Claim 80, in which the connection device comprises strip conductors.

40. A fuel cell device as claimed in Claim 39, in which the strip conductors are applied to the electrolyte device.

41. A fuel cell device as claimed in Claim 40, in which the connection device comprises a strip conductor for at least one anode device and a strip conductor for at least one cathode device, such that the strip conductors are connected at an edge of the electrolyte device to a connector.

42. A fuel cell device as claimed in Claim 40, in which the connection device for at least one anode device and at least one cathode device comprises a strip conductor that is guided from the anode side to the cathode side by the electrolyte device.

43. A fuel cell device as claimed in Claim 80, further comprising a switch device that is designed to modify the connection device of the anode devices and the cathode devices of the fuel cell device, so that an electrical output generated by the fuel cell device can best adapt to the requisites of a consumer.

44. A fuel cell device as claimed in Claim 43, in which the connection device comprises a strip conductor for at least one anode device and a strip conductor for at least one cathode device, such that the strip conductors are connected at an edge of the electrolyte device to a connector, and in which the switch device has a connector that can be connected to the conductor at the edge of the electrolyte device.

45. A fuel cell device as claimed in Claim 44, in which the connector comprises at least one plug board.

46. A fuel cell device as claimed in Claim 30, in which the electrolyte device is a proton-conducting electrolyte film.

47. A fuel cell device as claimed in Claim 30, in which the fuel cell device is a methanol fuel cell device, and the electrolyte device comprises nafion.

48. A fuel cell device as claimed in Claim 30, in which the fuel cell device is a hydrogen fuel cell device, and the electrolyte device comprises nafion.

49. A fuel cell device as claimed in Claim 30, in which the fuel cell device is manufactured by a surface-coating process.

50. A fuel cell apparatus as claimed in Claim 31, in which each two adjacent said fuel cell devices are interconnected by an electrically insulating connection device, such that at least one of the following arrangements is provided:

each two adjacent fuel cell devices are arranged such that the anode devices of the first of these fuel cell devices are facing the anode devices of the second of these fuel cell devices, and

the cathode devices of the first of these fuel cell devices are facing the cathode devices of the second of these fuel cell devices, and

each connection device has a supply distribution structure for fuel to be supplied to the anode devices or oxidising agent to be supplied to the cathode devices.

51. A fuel cell apparatus as claimed in Claim 31, in which each two adjacent said fuel cell devices are interconnected by an electrically insulating connection device, such that

each cathode side of a first of the two adjacent fuel cell devices of the anode device is facing the second of the two adjacent fuel cell devices, and

each connection device has a first supply distribution structure for fuel to be supplied to the anode devices and a second supply distribution structure for oxidising agent to be supplied to the cathode devices.

52. A fuel cell apparatus as claimed in Claim 51, in which the connection device has conducting elements that are arranged such that the connection device electrically conductively connects each anode device of a first of two adjacent fuel cell devices to the cathode device facing the anode device of the second of two adjacent fuel cell devices.

53. A fuel cell apparatus as claimed in Claim 50, in which the connection device includes strip conductors that are provided one of on and in the connection device.

54. A fuel cell apparatus as claimed in Claim 53, in which the connection device comprises a first strip conductor for at least one anode device and a second strip conductor for at least one cathode device, such that the first and second strip conductors are connected at the edge of the connection device to a connector.

55. A fuel cell apparatus as claimed in Claim 50, further comprising a casing in which the fuel cell apparatus is accommodated, in which the connector extends through a wall of the casing.

56. A fuel cell device as claimed in Claim 30, which is designed as a low-temperature fuel cell device.

57. A fuel cell device as claimed in Claim 30, which is designed to provide an electrical power output of less than one kW.

59. A system as claimed in Claim 5, in which the disposal device is designed to convert gases resulting from operation of the fuel cell device into at least one of liquid and solid substances.

60. A system as claimed in Claim 8, in which the pump device can be adjusted such that the quantity of fuel supplied by the pump device of the fuel cell device effects a constant output of the fuel cell device, such that the output of the fuel cell device serves as output quantity.

61. A system as claimed in claim 12, wherein the alkaline exchanger is a hydroxide ion exchanger.

62. A system as claimed in Claim 13, in which the fuel tank device is designed to hold hydrogen, further comprising an oxidising agent tank device to hold an oxidising agent.

63. A system as claimed in claim 14, wherein the oxidising agent is one of oxygen and hydrogen peroxide.

64. A system as claimed in claim 62, wherein the oxidising agent is one of oxygen and hydrogen peroxide.

65. A system as claimed in Claim 62, further comprising a pump device, for supporting the supply of oxidising agent to the fuel cell device.

66. A system as claimed in Claim 16, in which the pump device can be adjusted such that the quantity of oxidising agent supplied by the pump device of the fuel cell device effects a constant output of the fuel cell device, such that the output of the fuel cell device serves as an output quantity.

67. A system as claimed in Claim 13, further comprising a pump device, for supporting the supply of oxidising agent to the fuel cell device, in which the pump device is designed as a ventilator device for supplying atmospheric air from the environment.

68. A system as claimed in Claim 7, in which the fuel cell device, the fuel tank device, the pump device for the fuel, and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

69. A system as claimed in Claim 14, in which the fuel cell device, the fuel tank device, the oxidising agent tank device, and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

70. A system as claimed in Claim 15, in which the fuel cell device, the fuel tank device, the pump device for the oxidising agent, the oxidising agent tank device,

and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

71. A system as claimed in Claim 7, in which the fuel cell device and the pump device for the fuel are arranged on the consumer side, and the fuel tank device and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

72. A system as claimed in Claim 14, in which the fuel cell device is arranged on the consumer side, and the fuel tank device, the oxidising agent tank device, and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

73. A system as claimed in Claim 15, in which the fuel cell device and the pump device for the oxidising agent is are arranged on the consumer side, and the fuel tank device, the oxidising agent tank device, and the disposal device are designed as a module that can be inserted into the consumer to supply power and removed from the consumer.

74. A system as claimed in Claim 23, in which the pump device can be adjusted such that a quantity of fuel supplied by the pump device of the fuel cell device effects a constant output of the fuel cell device, such that the output of the fuel cell device serves as output quantity.

75. A system as claimed in Claim 27, in which the pump device can be adjusted such that the quantity of oxidising agent supplied by the pump device of the fuel cell device effects a constant output of the fuel cell device, such that the output of the fuel cell device serves as an output quantity.

76. A fuel cell apparatus as claimed in Claim 31, in which the anode devices are substantially the same size and shape as the corresponding cathode devices.

77. A fuel cell apparatus as claimed in Claim 31, further comprising ion-permeable current conductors, interconnected by a connection device and disposed between at least one of the electrolyte devices and the anode devices, and the electrolyte devices and the cathode devices.

78. A fuel cell apparatus as claimed in Claim 31, further comprising one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed on at least one of the anode devices and the cathode devices.

79. A fuel cell device as claimed in Claim 30, further comprising one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed in at least one of the anode devices and the cathode devices.

80. A fuel cell device as claimed in Claim 30, further comprising one of:

ion-permeable current conductors, interconnected by a connection device and disposed between at least one of

the electrolyte device and the anode devices, and

the electrolyte device and the cathode devices;

one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed on at least one of the anode devices and the cathode devices; and

one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed in at least one of the anode devices and the cathode devices.

81. A fuel cell apparatus as claimed in Claim 31, further comprising one of:

ion-permeable current conductors, interconnected by a connection device and disposed between at least one of

the electrolyte device and the anode devices, and

the electrolyte device and the cathode devices;

one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed on at least one of the anode devices and the cathode devices; and

one of fuel-permeable and oxidant-permeable current conductors, interconnected by a connection device and disposed in at least one of the anode devices and the cathode devices.

82. A fuel cell apparatus as claimed in Claim 81, in which each current conductor has a braid or a perforated film.

83. A fuel cell apparatus as claimed in Claim 81, in which each current conductor comprises at least one of nickel, gold, platinum, and stainless steel.

84. A fuel cell apparatus as claimed in Claim 81, in which each current conductor is substantially the same size as one of the respective anode device and the respective cathode device.

85. A fuel cell apparatus as claimed in Claim 81, in which the connection device comprises strip conductors.

86. A fuel cell apparatus as claimed in Claim 85, in which the strip conductors are applied to the electrolyte device.

87. A fuel cell apparatus as claimed in Claim 86, in which the connection device comprises a strip conductor for at least one anode device and a strip conductor

for at least one cathode device, such that the strip conductors are connected at an edge of the electrolyte device to a connector.

88. A fuel cell apparatus as claimed in Claim 86, in which the connection device for at least one anode device and at least one cathode device comprises a strip conductor that is guided from the anode side to the cathode side by the electrolyte device.

89. A fuel cell apparatus as claimed in Claim 81, further comprising a switch device that is designed to modify the connection device of the anode devices and the cathode devices of the at least two fuel cell devices, so that an electrical output generated by the fuel cell device can best adapt to the requisites of a consumer.

90. A fuel cell apparatus as claimed in Claim 89, in which the connection device comprises a strip conductor for at least one anode device and a strip conductor for at least one cathode device, such that the strip conductors are connected at an edge of the electrolyte device to a connector, and in which the switch device has a connector that can be connected to the conductor at the edge of the electrolyte device.

91. A fuel cell apparatus as claimed in Claim 90, in which the connector comprises at least one plug board.

92. A fuel cell apparatus as claimed in Claim 31, in which the electrolyte device is a proton-conducting electrolyte film.

93. A fuel cell apparatus as claimed in Claim 31, in which the fuel cell devices are methanol fuel cell devices, and the electrolyte device comprises nafion.

94. A fuel cell apparatus as claimed in Claim 31, in which the fuel cell devices are hydrogen fuel cell devices, and the electrolyte device comprises nafion.

95. A fuel cell apparatus as claimed in Claim 31, in which the fuel cell devices are manufactured by a surface-coating process.

96. A fuel cell device as claimed in Claim 49, wherein the surface-coating process is one of a semi-conductor technology processes and a electroplating processes.

97. A fuel cell apparatus as claimed in Claim 95, wherein the surface-coating process is one of a semi-conductor technology processes and a electroplating processes.

98. A fuel cell apparatus as claimed in Claim 31, which is designed as a low-temperature fuel cell device.

99. A fuel cell apparatus as claimed in Claim 31, which is designed to provide an electrical power output of less than one kW.

Abstract of the Disclosure

A system for supplying a consumer with electrical power includes a fuel cell device and a fuel tank device for holding fuel, as well as a disposal device for accommodating waste products. A fuel cell device includes a plurality of anode devices, and a plurality of corresponding cathode devices, and has a substantially flat electrolyte device, such that each anode device and its corresponding cathode device are arranged on the opposite sides of the electrolyte device. At least two fuel cell devices can together form a single cell, arranged on one plane. Each two adjacent fuel cell devices are interconnected by a connection device, which each have supply ducts for fuel to be supplied to the anode devices or oxidising agent to be supplied to the cathode devices.

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FUEL CELL SYSTEM AND FUEL CELL FOR SUCH A SYSTEM

Scope of the Invention

The present invention relates to a system for supplying a consumer with electrical power using a fuel cell device for generating electrical power, and a fuel tank device for holding fuel to be supplied to the fuel cell device.

The invention also relates to fuel cells for such a system, in particular a fuel cell device comprising at least one fuel cell device having a plurality of anode devices, and a plurality of cathode devices, where each cathode device is assigned a corresponding anode device.

In addition, the invention relates to a stack of such fuel cells (hereinbelow also called fuel cell stacks).

Prior Art

Systems with fuel cells of the abovementioned type as well as fuel cells of the abovementioned type for such systems are known in the prior art.

These known fuel cell systems are essentially restricted to the high-performance application range of several kW. Examples of fuel cell systems are found in the automobile industry or in power plant technology.

In the light-capacity range, that is, of the order of up to 1 to 2 kW, fuel cells are still barely being used nowadays as an alternative to batteries or storage batteries.

This is because known fuel cell systems, which should act as battery and storage battery substitute, exhibit poorer properties than batteries and storage batteries. In particular, known fuel cell systems cannot guarantee the same running period, the same safety, comparable size and comparable weight as batteries or storage batteries.

In addition, with known systems there are no measures in place to ensure disposal of the reaction products.

Whereas with a fuel cell current strengths of clearly over $1A/cm^2$ can be achieved, as a rule electrical voltages of the order of only 0.5 to 0.7V in the charged state (1.2V in the uncharged state) can be achieved with a single fuel cell. Since most small apparatus however requires a substantially higher operating voltage, it is necessary to combine several fuel cells into one fuel cell device to be able to produce the required voltage.

It is known to combine several fuel cells into a stacked fuel cell device (fuel cell stack). These known fuel cell stacks have, however, a considerable overall height and complex fuel supply devices, generally preventing their use in small apparatus.

It is also known to arrange several fuel cells on one plane and to connect them together. For example, DE 196 36 903 discloses such a planiform configuration. The configuration illustrated in this document comprises a plurality of single cells which are each provided gas-tight in a casing. Because when such a fuel cell is manufactured the majority of single fuel cells and the corresponding majority of seals must be placed in the casing, the manufacture of such a fuel cell device is relatively expensive and thus cost-intensive.

In view of these disadvantages of the prior art the object of the present invention is to improve the known fuel cell system as well as the fuel cell devices used therein.

Description of the Invention

The abovementioned task is solved by a system for supplying a consumer with electrical power of the type mentioned at the outset, which is distinguished by a disposal

device for disposing of the waste products originating from operation of the fuel cell device.

Through provision of a disposal device for the waste products of the processes running in a fuel cell the fuel side of the system can be operated without interacting with the environment at all, effectively overcoming a substantial drawback of known systems.

According to a preferred further development the disposal device can comprise a receptacle for holding waste products.

According to another advantageous further development the fuel tank device can be designed such that it serves as a receptacle. Due to these measures the structural size of the system can be reduced, which in particular enables it to be incorporated into small apparatus, such as for example portable computers, power tools, electrical domestic appliances, electrical telecommunications equipment, portable television sets, video recorders and the like.

According to another preferred further development the disposal device can have a filter device. This enables the waste products to be separated from one another. This in turn facilitates disposal of the elements arising from power generation. Furthermore, through such separation a portion of the waste products not impairing the fuel can be stored in the fuel tank device. This is incidentally one of the examples for the abovedescribed further development of the fuel tank device which also serves as a receptacle.

In accordance with an alternative further development the disposal device can also comprise an ion exchange device.

By way of advantage both the filter device and the ion exchange device can be designed to convert gases generated during operation of the fuel cell device into liquid and/or solid substances. Because of these measures only liquid and solid waste products remain after power is generated and these are substantially easier to handle than gaseous waste products.

In the system it must be ensured that the fuel cell device always has fuel available in sufficient concentration. In addition to this, the fuel must be in contact with the electrode arrangement, when positive ions pass through the electrolyte of the anode arrangement and when negative ions pass through the electrolyte of the cathode arrangement of the fuel cell device.

According to an advantageous further development of the abovedescribed system a pump device can be provided to support the fuel supply from the fuel tank device to the fuel cell device. The flow, which ensures that unused fuel is always available to the fuel cell, can be supported by such a pump device in particular with liquids. In addition, this flow also supports removal of waste products.

According to yet another further development the system can also be designed such that fuel supply is effected substantially by the pump device. In this connection the power supply can be controlled by targeted control of the pump device.

By way of advantage the pump device in the described embodiments can be designed in the form of a miniature pump. These measures serve to keep the structural size of the system to a minimum.

According to a particularly advantageous further development the pump device can be designed adjustably such that the quantity fed to the fuel cell device effects a constant output of the fuel cell device. In this connection repeated measurements of the output of the fuel cell device serve as output quantities.

An advantage of this further development is that power supply of a consumer is possible with constant current and constant voltage, therefore with constant output.

According to another further development the abovedescribed fuel cell devices can advantageously be provided as methanol fuel cell devices. Methanol fuel cell devices are characterised in particular by the fact that liquid fuel with high-energy density is used, resulting in a compact structure of a methanol fuel cell device. In methanol fuel cells in particular a methanol-water mixture is supplied as fuel to the anode device of

the fuel cell. The cathode device is supplied by an oxidant, such as air or pure oxygen, for example. Carbon dioxide occurs on the anode and water vapour occurs on the cathode as waste products of the reactions in the fuel cell.

According to an advantageous further development of the methanol fuel cell device a filter device can be used which converts carbon dioxide into a carbonate present in the solid phase. In particular, filter devices having calcium carbonate are suitable here.

As an alternative such conversion can be performed advantageously with an alkaline ion exchanger, in particular an alkaline ion exchanger based on synthetic resin, for example a hydroxide ion exchanger.

As an alternative to the methanol fuel cell device hydrogen fuel cell devices can also be utilised. In this case hydrogen is used as fuel and accordingly supplied to the anode device. The cathode device is likewise supplied with an oxidant, oxygen or air, for example. Water present in steam form occurs on the cathode as a reaction product. This can be collected in a receptacle. Alternatively, it can also be released to the atmosphere. Furthermore, in this embodiment the remaining low-oxygen air must be removed from the system. This can occur by being released to the atmosphere.

According to another preferred further development of the abovedescribed system the fuel tank device can be designed to accommodate a methanol-water mixture or hydrogen, and an oxidising agent tank device can be provided to hold an oxidising agent, for example pure oxygen or hydrogen peroxide. By way of these measures the fuel cell system can be operated as a fully closed-off system, similarly to a battery or a storage battery.

Similarly to the pump device on the fuel side a pump device can also be provided to support supply of the oxidising agent from the oxidising agent tank device to the fuel cell device.

According to another further development supply of the oxidising agent can advantageously be effected essentially by the pump device. As is the case of the pump

device for fuel, effective supply of the oxidising agent to the electrode device of the fuel cell device can be guaranteed

By way of advantage the pump device can be designed in the form of a miniature pump. This again ensures minimal structural size with high functionality.

As for the pump device on the fuel side the pump device on the oxidising agent side can also be provided adjustably such that the quantity of oxidising agent supplied by the pump device of the fuel cell device ensures constant output of the fuel cell device, in such a way that the output of the fuel cell device acts as output quantity. This embodiment can be implemented alternatively for or together with regulating the pump device on the fuel side.

The abovedescribed systems can, according to another further development, include a ventilator device for supplying atmospheric oxygen from the atmosphere. An advantage of this design is that the ambient air can be used as oxidising agent. A further advantage is that the size of the system can be smaller on account of the oxidising agent tank device being omitted. Altogether, the system can be manufactured as a smaller and more cost-effective unit. Since atmospheric oxygen is utilised, the efficiency of the system is, however, reduced when compared to a system operated on pure oxygen. The excess low-oxygen air can be released into the atmosphere in this further development

According to yet another advantageous further development of all the abovedescribed systems the overall system, therefore the fuel cell device, the fuel tank device, possibly the pump device for fuel and/or for the oxidising agent, the tank device for taking up the oxidising agent if required and the disposal device can be designed as a module which can be placed into the consumer for power supply and withdrawn from the consumer for refilling. This design enables easy replenishing of fuel and easy replacement of the system, whenever it becomes worn.

Alternatively and according to another highly advantageous further development the fuel cell device and possibly the pump device for fuel and/or for the oxidising agent of the

system can be arranged on the consumer side. In this case only the fuel tank device, the tank device for holding the oxidising agent and the disposal device are designed as a module which can be placed into the consumer for power supply and withdrawn from the consumer for refilling. In this further development only the actual user components of the system can be exchanged.

An advantage of this system is that it can be replenished after the fuel is used, without the occurrence of substances which are problematical to dispose of. Even if the system has to be disposed of as such, the individual components of the system can be recycled, without the occurrence of substances which are problematical to dispose of, as is the case with recycling many types of battery or many types of storage battery.

The underlying task of the invention is also solved by a system of the type described at the outset, which is characterised in that the fuel cell device is provided on the consumer side and the fuel tank device is designed as a module, which can be placed into the consumer for power supply and withdrawn from the consumer for refilling.

These measures allow the actual consumer components of the system to be provided as exchangeable units. Because single modules can be manufactured relatively cost-effectively, these modules can be used to operate a consumer as batteries or a storage battery is used, that is, when the fuel is consumed, a fresh module can be inserted. In addition to this, since the storage capacity of a fuel cell device relative to its volume is considerably greater than that of a battery or a storage battery, the service life of the fuel cell device can be increased while the size remains the same.

This system can be developed further advantageously in a variety of ways. In particular, the advantageous embodiments can be used which have already been discussed in connection with the system, comprising a disposal device. These advantageous embodiments are itemised hereinbelow; with respect to the advantages achievable by these embodiments reference is made to the above discussion of the advantageous embodiments to avoid repetition.

According to another further development the system can be equipped with a pump device provided on the consumer side, preferably a miniature pump, to support the fuel supply from the fuel tank device to the fuel cell device.

This pump device can also be fitted in such a way that the fuel is supplied substantially by the pump device.

According to a particularly advantageous further development the pump device can be fitted adjustably, and certainly such that the quantity of fuel provided by the pump device of the fuel cell device effects a constant output of the fuel cell device, such that the measured output of the fuel cell device serves as output quantity.

According to yet another further development a hydrogen fuel cell device can be utilised in the system as a fuel cell device.

Furthermore the system can have a pump device on the consumer side, preferably a miniature pump, to support supply of the oxidising agent to the fuel cell device.

According to a further development of the system the supply of the oxidising agent can be effected substantially by the pump device.

According to another advantageous further development the pump device can be adjusted such that the quantity of oxidising agent supplied to the fuel cell device effects a constant output of the fuel cell device, such that the output of the cell device serves as output quantity. The adjustable pump device for the oxidising agent can also be used here together with the adjustable pump device for fuel.

According to another further development the pump device can also be designed as a ventilator device for supplying ambient oxygen from the atmosphere.

The third aspect of the task underlying the invention, namely improvement of the fuel cell device, is solved by a fuel cell device of the type initially described, which is characterised in that each fuel cell device exhibits a single, essentially flat electrolyte

device, such that each anode device and its corresponding cathode device are placed on opposite sides of the electrolyte device.

Hereby it is no longer necessary compared to the prior art to place every single fuel cell made up of anode, electrolyte and cathode gas-tight into a casing. The manufacturing process and thus manufacturing costs of the fuel cell device can thus be simplified or reduced substantially.

Alternatively the known fuel cell device is improved by the fact that at least two fuel cell devices are provided with a plurality of anode devices, a plurality of cathode devices, where each cathode device is assigned a corresponding anode device, and a plurality of electrolyte devices, such that an anode device and a corresponding cathode device are arranged respectively on opposite sides of a corresponding electrolyte device and together form a single cell, where all single cells of a fuel cell device are arranged in one plane, and the at least two fuel cell devices are arranged above one another.

In particular, the voltage achievable with the known fuel cell device can hereby be increased as such by optimising dimensioning, that is, reduction in size, of the fuel cell device.

According to an advantageous further development of these alternatives corresponding anode devices and cathode devices can exhibit the same size and form. This guarantees effective generation of power with minimal structural size.

According to another advantageous further development of the abovedescribed fuel cell devices ion-permeable, preferably proton-permeable current conductors, which are connected together by a switching device, can be provided between the electrolyte device(s) and the anode devices and/or between the electrolyte device(s) and the cathode devices.

As an alternative to this fuel-permeable or oxidising agent-permeable current conductors can also be used which are provided on the anode devices and/or the

cathode devices, in such a way that the current conductors are connected together by a connection device.

According to a further alternative fuel-permeable or oxidising agent-permeable current conductors, which are connected to one another by means of a connection device, can be provided in the anode devices and/or in the cathode devices.

The above three alternatives for arranging the current conductors relative to the anode devices or the cathode devices can each be inserted singly, that is, for all electrodes of the fuel cell device, or they may also be combined in any other way.

In this connection each current conductor can preferably be designed as a braid or a thin perforated plate or a perforated film. Firstly, good contact is ensured between current conductor and electrode; secondly, the fuel and the oxidising agent can make contact with the electrode devices without difficulty.

Each current conductor can comprise nickel, platinum, gold, and/or stainless steel. The durability of the current conductors can be increased considerably by use of these materials.

According to an advantageous further development of the current conductor the latter can be approximately the same size as the assigned anode device or the assigned cathode device. In this design maximum possible contact between current conductor and electrode device is guaranteed and the resistance between current conductor and electrode device is thereby minimised.

According to a particularly advantageous further development the connection device can include strip conductors. This measure can produce particularly simple connection of the individual fuel cells. In particular, an integrated circuit can be realised hereby.

These strip conductors can be attached to the electrolyte device, for example.

In particular, with respect to current conductors which are also attached to the electrolyte device (or between electrolyte device and anode or cathode device), the advantage of relatively simple manufacture arises. Therefore in one operating step the entire current conductor /strip conductor sample can be designed on the electrolyte device, for example using processes such as masking, photolithography, etching, layering and the like known from semi-conductor technology.

According to an advantageous further development the connection device can exhibit a strip conductor for at least one anode device and a strip conductor for at least one cathode device, such that the strip conductors are connected at the edge of the electrolyte device to a connector.

Moreover, the connection device for at least one anode device and at least one cathode device can have a strip conductor which is guided from the anode side to the cathode side on the electrolyte device. The individual cells can accordingly be connected in series.

Any arbitrary connection of the individual fuel cells can be realised by random combination of both these alternatives. By way of example, all fuel cells can be connected to one another in series by the second alternative and the tap, therefore the strip conductor which is attached at the edge of the electrolyte device to the connector, can be provided on the first and last fuel cell of this series. On the other hand each fuel cell can be tapped per se by the first alternative and connected externally in any manner. Both these alternatives and a combination of both alternatives open up a large number of options for adapting a fuel cell device to the various current and voltage requirements of a consumer.

According to an advantageous further development a switch device, which is designed to modify the connection device of the anode devices and the cathode devices of at least one or at least two fuel cell devices, can be provided. Optimum adaptation of the electrical power generated by the fuel cell device to the requirements of a consumer is enables thereby. Moreover, this adaptation can also be easily altered and thus adapted to the requirements of one or various consumers.

By way of advantage the switch device of the fuel cell device can comprise a connection device which can be connected to the connection device at the edge of the electrolyte device. This connection device may comprise a plug board for example.

According to a further development of the abovementioned fuel cell devices the electrolyte device can be provided in the form of a proton-conducting electrolyte film. Such a film can be worked and processed relatively easily, keeping manufacturing costs of the fuel cell device to a minimum.

The fuel cell device can, according to an advantageous further development, comprise methanol fuel cell devices. In this case an electrolyte device including nafion is preferably suitable.

The advantages already discussed in connection with the embodiments of the systems of a methanol fuel cell device also apply here.

According to an alternative further development the fuel cell device can also have hydrogen fuel cell devices; in this case electrolyte devices including nafion are also suitable.

Here too the advantages of a hydrogen-fuel cell device already discussed in connection with the embodiments of the systems apply.

The abovedescribed fuel cell devices can preferably be manufactured by semi-conductor processes, electroplating processes or other known surface-coating processes.

According to a particularly advantageous further development of all abovedescribed fuel cell devices these can have at least two fuel cell devices, such that each two adjacent fuel cell devices are connected to one another by an electrically insulating connection device, and each two adjacent fuel cell devices are arranged such that the anode devices of the first of these fuel cell devices face the anode devices of the second of

these fuel cell devices or the cathode devices of the first of these fuel cell devices face the cathode devices of the second of these fuel cell devices, and each connection device has a supply distribution structure for the fuel to be supplied to the anode devices or the oxidising agent to be supplied to the cathode devices.

In this way n fuel cell devices can be interconnected. For this n – 1 of the abovedescribed connection devices are required. For the first and last fuel cell device elements can be provided which exhibit supply ducts which are open on one side of the element only. Alternatively, the abovedescribed connection devices can be used, where the supply distribution structure is to be connected to one side of the connection devices to prevent the fuel or oxidising agent from escaping.

By means of this further development stacks of fuel cell devices can be formed and any voltages corresponding to the respective requirements can be created thereby. In particular, fuel cell devices can be created by these embodiments, whose output compared to batteries and storage batteries can be lowered considerably at the same voltage. By means of this so-called monopolar connection of the individual fuel cell devices minimal structural sizes can be realised, since only one supply distribution structure is required for every two cells. Fuel cell devices whose size corresponds to conventional batteries and storage batteries can thus be realised.

Alternatively to this and according to another further development the fuel cell device can also have a stack shape with at least two fuel cell devices, in which each two adjacent fuel cell devices are interconnected by an electrically insulating connection device, such that each cathode side of a first of the two fuel cell devices of the anode device faces the second of the two fuel cell devices, and each connection device has a first supply distribution structure for the fuel to be supplied to the anode devices and a second supply distribution structure for the oxidising agent to be supplied to the cathode devices.

This alternative, with which any voltage can likewise be produced, can be used in particular whenever the overall height is less critical. Incidentally, the advantages, which

have already been discussed in connection with the monopolar connection of the fuel cell devices, also emerge for such a further development with these connection devices.

According to an advantageous further development of the above latter alternatives each connection device can have conducting elements which are arranged such that it electrically conductively connects each anode device of a first of the two adjacent fuel cell devices with the cathode device of the second of the two adjacent fuel cell devices facing it and corresponding to it.

This further development enables different, respectively superposed cells of different fuel cell devices to be connected to one another in a stack. In this connection a bipolar connection is realised in each stack for superposed fuel cells of different fuel cell devices. The different stacks made up in this way need to be connected to one another by the uppermost and lowest cell of the stack only. Thereby the connection expense in the fuel cell device can be reduced.

The abovedescribed stacked fuel cell devices can, as can the fuel cell devices having one fuel cell device only, have a connection device in the form of strip conductors according to an advantageous further development.

In this connection the strip conductors can be provided advantageously on or in the connection device. The fuel cell device can be consequently manufactured in particularly simple fashion. In particular, fuel cell devices and the connection devices can be formed by means of processes known from semi-conductor technology. Accordingly, the fuel cell devices and the connection devices merely need to be combined and the fuel cell devices connected.

According to a preferred further development a fuel cell device can be provided, in which the connection device includes a strip conductor for at least one anode device and a strip conductor for at least one cathode device, where the strip conductors are connected at the edge of the connection device to a connector.

Apart from connection of the individual fuel cells random connecting of the individual fuel cell devices is also possible. Here the individual cells can be connected in different groups in different fuel cell devices at random, by means of which a plurality of possible currents and voltages can be obtained. Such fuel cell devices can therefore be flexibly used for a wide variety of applications.

According to an advantageous further development of this embodiment the abovedescribed fuel cell devices can be provided in a casing, and the connectors can extend through a wall of this casing. By means of this particular measure the entire fuel cell device can be connected to a corresponding connector and/or switchgear.

Low-temperature fuel cell devices are particularly suitable for use in small apparatus, such as portable computers and the like,.

The abovedescribed fuel cell devices are particularly suitable for outputting less than approximately one kW.

The discussed systems and the fuel cell devices utilised therein are optimised for the low-output range, in particular with respect to their power output and size, but can also be used with corresponding dimensioning in other output ranges.

Although not mentioned explicitly, a plurality of the abovedescribed features can be combined together, so that the advantages described for the individual features can be achieved in combination. In particular, all described fuel cell devices are suited for use in the systems described at the outset.

Preferred embodiments of the present invention are described hereinbelow with reference to the accompanying diagram, in which:

Figure 1 shows a first embodiment of the system for supplying an electrical consumer with power according to the present invention,

Figure 2 shows a second embodiment of the system for supplying an electrical consumer with power according to the present invention,

Figure 3 shows a third embodiment des system for supplying an electrical consumer with power according to the present invention,

Figure 4 shows a fourth embodiment of the system for supplying an electrical consumer with power according to the present invention,

Figure 5 shows a first embodiment of a fuel cell device according to the present invention, in particular for use in one of the systems of Figures 1 to 4,

Figure 6 shows a second embodiment of a fuel cell device according to the present invention, in particular for use in one of the systems of Figures 1 to 4,

Figure 7 shows a third embodiment of a fuel cell device according to the present invention, in particular for use in one of the systems of Figures 1 to 4,

Figure 8 shows a fourth embodiment of a fuel cell device according to the present invention, in particular for use in one of the systems of Figures 1 to 4,

Figure 9 shows a fifth embodiment of a fuel cell device according to the present invention, in particular for use in one of the systems of Figures 1 to 4,

Figure 10 shows a sixth embodiment of a fuel cell device according to the present invention, in particular for use in one of the systems of Figures 1 to 4, and

Figure 11 shows a detailed view of a current conductor in a fuel cell device according to the present invention.

Figure 1 illustrates a first embodiment of a system 10 according to the present invention for supplying an electrical consumer with power. The illustration of the system is, in

particular with respect to the illustrated ratios of dimensions, to be understood diagrammatically only.

The system comprises a fuel cell device 11 for generating the electrical power, a fuel tank device 12 for holding the fuel and a disposal device 13 for disposing of the waste products resulting from operation of the fuel cell.

The fuel cell device 11 comprises an anode area 11a, an electrolyte device 11c which is permeable to ions, in particular protons and impermeable to electrons, and a cathode area 11b. The anode area and the cathode area can be designed in particular by a plurality of anodes or cathodes, as is explained in detail in connection with the description of Figures 5 to 9.

Figure 1 illustrates a system 10, in which fuel is supplied to the anode area 11a, which is not fully converted, that is, which does not reach the cathode area 11b fully after conversion into ions via the electrolyte device 11c. Accordingly, waste substances occur from operation of the fuel cell in the anode area 11a, which are disposed of by the disposal device 13 which is designed as a filter device in the present embodiment.

The fuel is supplied from the fuel tank device 12 to the fuel cell device 11 by a pump device 14.

An oxidising agent is supplied to the cathode area 11b in the illustrated embodiment. When the fuel cell is operating the oxidising agent reacts with the fuel constituents which have reached the cathode area via the electrolyte device 11c. The illustrated embodiment is particularly suitable, if innoxious substances occur in the cathode area, which can be released to the atmospheric air without risk.

An example for a fuel cell device of the previously described type is a methanol fuel cell device. A methanol-water mixture is used here as fuel. Oxygen, for example in the form of atmospheric air, is supplied as oxidising agent to the cathode area. A ventilator 16, or alternatively a pump device, is used for this purpose.

Conditional on a catalyst the methanol reacts in the methanol-water mixture in the anode area 11a to protons, carbon dioxide and electrons. The protons migrate through the proton-permeable membrane 11c, which can be formed from nafion for example, into the cathode area 11b where they react with oxygen ions from the atmospheric air and which have been ionised by a catalyst. Water vapour, which is released along with the unused portion of the air into the atmosphere occurs here as waste product.

The electrons resulting from reaction are conveyed from the anode area to the cathode area in the form of electrical current.

The carbon dioxide originating in the anode area is flushed along with the water from the anode area into the filter device 13. This process, as for the supply of fuel to the fuel cell device, is supported by the pump device 14.

In the filter device 13 the carbon dioxide is converted into carbonate. In the illustrated embodiment a calcium dioxide filter is used, in which the carbon dioxide is converted into calcium carbonate with the formation of water.

An ion exchanger, in particular an alkaline ion exchange device based on synthetic resin, can be used as an alternative to the filter device. A synthetic resin matrix, on which hydroxide ions are stored, is suitable for this for example. In such an ion exchange device the carbon dioxide is converted into calcium carbonate, which accumulates on the matrix, with the formation of water.

The water resulting from filtering is supplied back to the fuel tank device 12 along with the unused portion of the methanol-water mixture.

In continuous operation the methanol is caused to react in the methanol-water mixture, which is why the concentration of the methanol in the methanol-water mixture is reduced to a value at which the abovedescribed reaction can no longer be carried out efficiently. The filter device is added by disposal of the carbon dioxide resulting from reaction. The available fuel and the filter device are effectively such that the concentration value is reached and the filter device is added at the same time.

According to the embodiment in Figure 1 the fuel tank device 12 and the filter device 13 are designed as a module, while the fuel cell device, the pump devices, the ventilator device and the supply ducts and outlets not described in greater detail are provided on the consumer side. This module can, as indicated by the arrow in Figure 1, be withdrawn from the consumer and reprocessed. In addition to this the fuel tank device is filled with fuel and the filter device or the ion exchange device is brought to its original state by chemical or physical means or completely exchanged.

In the illustrated embodiment some 5ml methanol are required for a consumer to operate for 10 hours with 20 Watt. At a concentration of 4 vol.% methanol in the methanol-water mixture approximately 125ml fuel mixture are required accordingly.

Figure 2 illustrates a second embodiment of the system 20 according to the present invention for supplying an electrical consumer with power. Depiction of the system, in particular with respect to the illustrated ratios of size, is to be understood schematically only. In order to avoid repetition hereinbelow reference is made only to the differences to the system illustrated in Figure 1 and with respect to the other components reference is made to the corresponding description of Figure 1. The reference numerals, with which corresponding components are designated, hereby differ by the first digit respectively.

An essential difference between the system 20 and the system 10 is that the system 20 is provided for fuels which are fully combusted. Accordingly, no waste substances occur in system 20 on the anode side. The anode area 21b consequently has no discharge and no disposal device.

The fuel cell device illustrated in Figure 2 may be realised in the form of a hydrogen fuel cell device. In such a device hydrogen, which is fully converted into protons by means of a catalyst, is supplied to the anode. These protons pass through the proton-permeable membrane to the cathode area. In the cathode area oxygen is converted from the atmospheric air into oxygen ions, likewise by means of a catalyst. The oxygen ions

finally react with the protons to water vapour. The electrons resulting from these reactions are taken off as current.

The module removable from the system is formed in the embodiment illustrated in Figure 2 by the fuel tank device 22.

Figure 3 illustrates a third embodiment of a system 30 according to the present invention for supplying an electrical consumer with power. Depiction of the system, in particular with respect to the illustrated ratios of size, is to be understood schematically only. The system 30 is similar to the system 10 illustrated in Figure 1. Therefore, to avoid repetition hereinbelow reference is made only to the differences to the system illustrated in Figure 1 and with respect to the other components reference is made to the corresponding description of Figure 1. The reference numerals, with which corresponding components are designated, hereby differ by the first digit respectively.

The system according to Figure 3 differs from the system according to Figure 1 by the fact that the oxidising agent is not removed from the atmospheric air and the waste products on the cathode side are not released to the atmosphere. This system accordingly is particularly suitable for fuels whose conversion produces environmentally-unfriendly waste products.

The oxidising agent is made available in an oxidising agent tank device 35, from where it makes its way into the cathode area 31a of the fuel cell device 31 by way of a pump device 36. The waste products of this process are guided to a disposal device 33 via an outlet pipe. The disposal device 33 comprises an ion exchange device 33-1 and a receptacle 33-2.

The pump device 36 is designed adjustably in this embodiment, and certainly so that the quantity of fuel supplied to the fuel cell device effects a constant output of the fuel cell device 31. The output released by the fuel cell device 31 is used as output quantity. Measurements of the output of the fuel cell device are made continuously by a meter (not illustrated) and in the pump rate is increased or decreased dependent on the measured output.

A methanol fuel cell device can again be employed as an example of such a fuel cell device.

Pure oxygen is supplied from the oxidising agent tank device 35 to the cathode area as oxidising agent by means of a pump device 36, designed in the form of a micro pump. Accordingly, water vapour is the only waste product occurring on the cathode side. The resulting water vapour is conveyed to the receptacle 33-2 via a pipe and stored there. On the anode side carbon dioxide forms as waste product in system 30, and is converted into calcium carbonate in an ion exchange device 33-1, as described hereinabove, with formation of water. The resulting water is finally fed to the fuel tank device 32.

An advantage of system 30 as compared to system 10 is that no waste products are released to the atmosphere and that more efficient generation of power can occur by the use of pure oxygen.

In the embodiment illustrated in Figure 3 the module which can be removed from the system is formed by the fuel tank device 32, the ion exchange device 33-1, the receptacle 33-2 and the oxidising agent tank device 35.

Figure 4 illustrates a fourth embodiment of a system 40 according to the present invention for supplying an electrical consumer with power. Depiction of the system, in particular with respect to the illustrated ratios of size, is to be understood schematically only. The system 40 is similar to the systems 20 and 30 illustrated in Figure 2 and in Figure 3. In order to avoid repetition therefore, hereinbelow reference is made only to the differences to the systems illustrated in Figures 2 and 3 and with respect to the other components reference is made to the corresponding description of Figures 2 and 3. The reference numerals, with which corresponding components are designated, hereby differ by the first digit respectively.

As with system 20 in Figure 2, system 40 is operated with a fuel which is fully converted on the anode side. There are accordingly no waste products on the anode side, and as

a result thereof neither a discharge nor a disposal device is provided on the anode side. And there are no differences apparent between system 30 and system 40.

Hydrogen in particular is suitable for operating system 40, as for the operation of system 20 in Figure 2. Hydrogen is converted into protons on the anode side without waste products. These protons migrate via the electrolyte device and react on the cathode side, to which pure oxygen is supplied from the oxidising agent tank device 45, with catalysed oxygen ions into water vapour. This water vapour can be condensed into water by means of a capacitor and then stored in the receptacle 43.

The module which can be removed from the system is formed in the embodiment illustrated in Figure 4 by the fuel tank device 42, the receptacle 43 and the oxidising agent tank device 45.

The illustrated embodiments of the systems are to be understood by way of example only and not as restrictive. By way of example a plurality of fuels, gaseous or liquid, and a plurality of oxidising agents, can also be used in the gaseous or liquid state.

The only stipulation is that the fuel in question can be dissipated by means of a catalyst device into ions which can migrate via the electrolyte device, and react on the cathode side with ions which result from conversion of an oxidising agent into ions.

In the embodiments illustrated in Figures 1 to 4 proton-permeable electrolytes were used. Depending on the fuel being used, however, other electrolyte devices can also be used which are permeable for positive or negative ions.

It should be noted that when electrolyte devices which are permeable for negative ions are used the fuel is to be returned to the cathode. With fuel which is fully converted all waste products accordingly accumulate on the anode side.

Moreover, all embodiments of the anode devices, the cathode devices, the electrolyte devices, the catalysts, and various materials for the fuel cell devices known to the expert in the domain of fuel cells can be used in the abovedescribed embodiments.

Embodiments of fuel cell devices according to the present invention are explained hereinbelow. These fuel cell devices are particularly suited to the abovedescribed systems, but can also be utilised for a wide range of applications

Figure 5 illustrates a first embodiment of a fuel cell device according to the present invention schematically in section. Depiction of the fuel cell device is to be understood schematically only, in particular with respect to the illustrated ratios in size.

Figure 5 in particular shows a fuel cell device 50 for use in a fuel cell device according to the present invention .

The fuel cell device 50 comprises an electrolyte device 55 in the form of an ion-conducting membrane, on which three anode devices 51 and three cathode devices 52 are provided.

The anode devices 51 and the cathode devices 52 can be connected to the membrane using methods known in the domain of fuel cell technology. Alternatively, the anode devices 51 and the cathode devices 52 can also be applied to the membrane 55 using processes known from semi-conductor technology, electroplating processes or other surface-coating processes.

In this configuration a cathode device 52 is assigned to each anode device 51. The anode devices 51 and the cathode devices 52 are the same shape and size. As a result, the same voltage and the same current are delivered by each anode/cathode device. The anode devices 51 and the cathode devices 52 can also be different in size and shape, though this leads to the fact that firstly the individual devices no longer give out a defined current, and secondly that the current yield is reduced in the case of predetermined structural size, as compared to identical form and size.

Strip conductors 54, which serve to connect the anode devices 51 and the cathode devices 52, are also applied to the membrane 55. This can occur by way of processes

known from semi-conductor technology, electroplating processes or other surface-coating processes, for example.

Figure 5 in particular shows an anode device connection 56a on the edge of the membrane 55 and a cathode device connection 56b.

In addition, the three individual cells are connected in series in the illustrated embodiment. This is realised by two strip conductors 56c, which are each guided from the anode side to the cathode side via the membrane. Methods known from semi-conductor technology can also be employed to form such strip conductors.

Furthermore, the embodiment illustrated in Figure 5 comprises current conductors 56d each of which is provided between the electrolyte device and the anode devices 51 or the cathode devices 52. The current conductors have openings for ensuring transport of ions through the electrolyte device. To increase the service life of same the current conductors 56d comprise an inert material, such as for example nickel, gold, platinum, stainless steel or alloys of the same.

The overall strip conductor/current conductor structure can be designed in the embodiment illustrated in Figure 5 in a single step, for example employing procedures known from semi-conductor technology, such as masking, photolithography, etching, coating and the like. Alternatively, electroplating coating processes or other surface-coating processes may also be employed.

The fuel cell device illustrated in Figure 5 further comprises a supply device for the fuel and the oxidising agent (not shown). In this connection the fuel is supplied to the anode devices; the oxidising agent is fed to the cathode devices.

It must be ensured that fuel and oxidising agent do not mix in order to guarantee the operating safety and functionality of the fuel cell. This is guaranteed in the illustrated embodiment by the fact that the membrane 55 used is impermeable for both the fuel and the oxidising agent. With respect to the prior art it is no longer necessary for the individual cells to be sealed off from one another. Rather the fuel on the *one hand* and

the oxidising agent on the other hand can be guided along the membrane. In particular, with use of strip conductors 56c, which are guided from the anode side to the cathode side, care should be taken that no leakages occur during operation to hinder the functioning of the fuel cell devices.

As explained in detail with reference to Figures 7 to 9, several of the illustrated fuel cell devices can be combined into one fuel cell device, in this instance designated as a fuel cell stack.

Figure 6 illustrates a second embodiment of a fuel cell device according to the present invention in a diagrammatic plan view. In particular, Figure 6 shows a fuel cell device 60 for use in a fuel cell device according to the present invention. The fuel cell device 60 is similar to the fuel cell device 50 illustrated in Figure 5. Therefore in order to avoid repetition hereinbelow reference is made only to the differences to the fuel cell device illustrated in Figure 5 and with respect to the other components reference is made to the corresponding description of Figure 5.

The fuel cell device 60 comprises nine anode devices 61 which are arranged on a continuous membrane 65. In addition, nine cathode devices are provided which are each below the anode devices 61 in the plane of projection. Current conductor devices in the form of a perforated structure are provided on the electrolyte device 65 also under the anode devices 61 and thus are not visible in the plan view.

The essential difference between the embodiments illustrated in Figure 5 and in Figure 6 is in the switching device. In the fuel cell device 60 only strip conductors 66a and 66b, which are guided to the edge of the membrane 65, are used. The nine strip conductors 66a are connected to the anode devices 61. The nine strip conductors 66b (of which three only are shown in dashed lines, as they are on the underside of the membrane) are connected to the cathode devices.

On the edge of the membrane all strip conductors are connected to connectors in the form of contact pins 67a and 67b.

These contact pins 67a and 67b are arranged such that they can be engaged with a plug board of a switch device 69.

The switch device 69 is designed such that the anode devices 61 and the cathode devices 62 can be connected in various ways known to the expert in parallel (for addition of currents) and in series (for addition of voltages). A plurality of different voltages U and currents I can be made available at the outlet of the switch device 69.

Apart from the toggling illustrated in Figure 5 and Figure 6 any combination of the illustrated embodiments can be implemented, according to application. By way of example it is possible to firmly connect an array of the membrane/electron devices toggled with one another in series in Figure 6 respectively and to variably interconnect the rows by the switch device.

In connection with the embodiments of Figures 5 and 6 it is pointed out that the use of strip conductors is to be understood by way of example only and not restrictively. Any other connection devices may be employed; for example the anode devices and the cathode devices can also be connected by wires.

Figure 7 diagrammatically illustrates a third embodiment of a fuel cell device according to the present invention. In this figure also the size ratios are not shown realistically for the sake of clearer representation. In particular, Figure 7 shows a fuel cell device 70 which comprises three fuel cell devices 70a, 70b and 70c, similar to those described in Figure 5 and Figure 6.

Each of the fuel cell devices 70a, 70b and 70c has a plurality of anode devices 71 and a plurality of cathode devices 72 which are arranged on a membrane 75. As indicated in the fuel cell device 70a, the individual cells of the fuel cell devices 70a, 70b and 70c are connected together in series by strip conductors, resulting in an increase in voltage.

The fuel cell devices 70a, 70b and 70c are electrically connected in series according to Figure 7.

In the fuel cell device 70 the fuel cell devices 70a and 70b, as well as 70b and 70c are interconnected by means of connection devices 77a and 77b. In this respect each two fuel cell devices 70a, 70b and 70c are arranged such that the anode sides of the devices 70a and 70b lie opposite the cathode sides of the devices 70b and 70c.

The connection devices 77a and 77b each comprise an insulation material, so that the anode devices 71 and the cathode devices 72 of two adjacent fuel cell devices are electrically insulated from one another.

The connection devices 77a and 77b each comprise a distribution structure 79a for supplying fuel B to the anode devices and a distribution structure 79b for supplying oxidising agent O to the cathode devices. The distribution structure can be designed arbitrarily. By way of example it can be present in the form of a channel structure or a porous structure. Furthermore, fuel and oxidising agent can be supplied parallel to one another (see Figure 7); it is also possible to supply fuel and oxidising agent alternatingly. Supply of fuel B and oxidising agent O is indicated in Figure 7 by arrows.

A closing plate 78a and 78b is provided respectively on the outsides of the fuel cell devices. As evident from Figure 7 each closing plate has only one distribution structure.

The distribution structures illustrated in Figure 7 are connected to a fuel supply and an oxidising agent feed, as shown for example in connection with the embodiments described in Figures 1 to 4.

According to Figure 7 the strip conductors are applied to connect the electrodes to the membrane 75. Alternatively the strip conductors can also be applied to the connection devices 77a and 77b and/or the closing plates 78a and 78b. The previously mentioned methods can be used for this purpose.

Figure 8 diagrammatically illustrates a fourth embodiment of a fuel cell device 80 according to the present invention in section. The fuel cell device 80 is similar to the fuel cell device 70 illustrated in Figure 7. Therefore in order to avoid repetition hereinbelow reference is made only to the differences to the fuel cell device 70 illustrated in Figure 7

and with respect to the other components reference is made to the corresponding description of Figure 7.

The fuel cell devices 80a, 80b and 80c are arranged such that each of the cathode sides or the anode sides of two adjacent fuel cell devices lies opposite each another. As in the embodiment in Figure 7 the fuel cell devices 80a and 80b or 80b and 80c are also interconnected by connection devices 88a and 88b.

According to the illustrated configuration the fuel cell devices 80a, 80b and 80c are connected to one another in series (as shown in Figure 8).

As compared to the configuration in Figure 7 it is sufficient in configuration 80 that the connection devices 88a and 88b each have only one distribution structure for supplying the oxidising agent or the fuel.

An added difference between the fuel cell devices 70 and 80 consists of the fact that in the device 80 fuel-permeable or oxdant-permeable current conductors 83 in the form of a braid or a perforated plate are provided on the anode devices 81 or the cathode devices 82. These current conductors are connected to strip conductors which are applied to the membrane 85 or to the connection device 88a or 88b. Alternatively, the current conductors can also be connected by wires for switching between electrodes. Both the strip conductors and the wires can be guided by the connection device 88b. This is illustrated by way of example in Figure 8 for the lowest anode connection 81a.

Figure 9 diagrammatically illustrates a fifth embodiment of a fuel cell device 90 according to the present invention in section. The fuel cell device 90 corresponds to the fuel cell device 80 illustrated in Figure 8. The sole difference between both devices is that the device 90 has a number of electrolyte devices 95 corresponding to the number of devices 91 or cathode devices 92. Because in this embodiment there is no separation between fuel and oxidising agent due to a continuous membrane, with the configuration of single cells it must be ensured that separating the fuel side and oxidising agent side of a fuel cell device is otherwise guaranteed. As a result sealing devices 99 are provided in the embodiment illustrated in Figure 9.

Incidentally, to avoid repetitions with respect to the remaining components reference is made to the corresponding description of Figure 8.

Figure 10 diagrammatically illustrates a sixth embodiment of a fuel cell device 100 according to the present invention in section. The fuel cell device 100 corresponds to the fuel cell device 70 illustrated in Figure 7. It comprises in particular three fuel cell devices which each comprise anode devices 101 (101-1, 101-2), cathode devices 102 (102-1, 102-2), and an electrolyte device 105 (105-1, 105-2).

The most important difference between both devices is that the connection device 107 has conducting elements 110a and 110b. Each connection device 107 is accordingly divided into conducting areas 110a and 110b (horizontal hatching in Figure 10) and non-conducting areas (vertical hatching in Figure 10).

The conducting elements 110a and 110b are arranged such here that they electrically conductively connect each anode device 101-1 of a first of two adjacent fuel cell devices 101-1, 105-1, 102-1 to the cathode device 102-2 facing it and corresponding to it of a second of two adjacent fuel cell devices 101-2, 105-2, 102-2.

This enables different, respectively superposed cells of different fuel cell devices to be connected to one another in a stack. In this connection a bipolar connection is made in each stack for superposed fuel cells of different fuel cell devices. The different stacks made up in this way need to be connected to one another by the uppermost and lowest cell of the stack only. Thereby the connection expense in the fuel cell device can be reduced.

The abovedescribed configuration also results in a distribution structure modified in comparison to Figure 7. In particular, the anode devices 101 and the cathode devices 102 are circulated laterally by the fuel or the oxidising agent in the embodiment illustrated in Figure 10.

Incidentally, to avoid repetitions with respect to the remaining components reference is made to the corresponding description of Figure 7.

Figure 11 illustrates an alternative embodiment of a current conductor according to the present invention in section. Figure 11 shows a fuel cell which is composed of an anode device 111, a cathode device 112 and an electrolyte device. Figure 11 also depicts a current conductor which is provided in the anode device 111 or in the cathode device 112.

The current conductor 116 preferably comprises a perforated film which ensures passage for ions, as well as the fuel and the oxidising agent. With respect to the material to be used the same applies that has already been carried out with the current conductors described in Figure 5 and in Figure 8.

The embodiments described in connection with Figures 1 to 11 are to be understood by way of example and not restrictively.

In particular, the number of fuel cell devices, the number of cells per fuel cell device, the permeable membrane or the single membranes, the respectively illustrated connections (including use of switch device), the different connection devices (monopolar plate, bipolar plate), are independent features and can be combined with one another at random.

Claims

1. A system (10; 30; 40) for supplying a consumer with electrical power, comprising:

   a fuel cell device (11; 31; 41) for generating electrical power,

   a fuel tank device (12; 32; 42) for holding the fuel to be supplied to the fuel cell device,

   characterised by

   a disposal device (13; 33-1, 33-2; 43) for disposing of the waste products resulting from operation of the fuel cell device.

2. A system as claimed in Claim 1, in which the disposal device (33-2; 43) has a receptacle for holding the waste products.

3. A system as claimed in Claim 2, in which the fuel tank device (12; 32) is designed such that it serves as a receptacle.

4. A system as claimed in any one of Claims 1 to 3, in which the disposal device (13) has a filter device.

5. A system as claimed in any one of Claims 1 to 3, in which the disposal device (33-1) has an ion exchange device.

6. A system as claimed in Claim 4 or 5, in which the disposal device (13; 33-1) is designed to convert gases resulting from operation of the fuel cell device into liquid and/or solid substances.

7. A system as claimed in any one of the foregoing claims having a pump device (14; 34; 44), preferably a miniature pump, for supporting the fuel supply from the fuel tank device (12; 32; 42) to the fuel cell device (11; 31; 41).

8. A system as claimed in Claim 7, in which the fuel is supplied essentially by the pump device (14; 34; 44).

9. A system as claimed in Claim 7 or 8, in which the pump device (14; 34; 44) can be adjusted such that the quantity of fuel supplied by the pump device (14; 34; 44) of the fuel cell device (11; 31; 41) effects a constant output of the fuel cell device (11; 31; 41), such that the output of the fuel cell device serves as output quantity.

10. A system as claimed in any one of the foregoing claims, in which the fuel cell device (11; 31) is designed as a methanol fuel cell device.

11. A system as claimed in Claim 10 in conjunction with Claim 4, in which the filter device (13) is provided to convert carbon dioxide to a carbonate.

12. A system as claimed in Claim 10 in conjunction with Claim 5, in which the ion exchange device (33-1) has an alkaline exchanger, preferably a hydroxide ion exchanger, based on synthetic resin.

13. A system as claimed in any one of Claims 1 to 9, in which the fuel cell device (41) is designed as a hydrogen fuel cell device.

14. A system as claimed in any one of Claims 10 to 13, in which the fuel tank device is designed to hold a methanol-water mixture (32) or hydrogen (42), and an oxidising agent tank device is provided to hold an oxidising agent (35; 45), preferably oxygen or hydrogen peroxide.

15. A system as claimed in any one of the foregoing claims having a pump device (16; 36; 46), preferably a miniature pump, for supporting the supply of oxidising agent to the fuel cell device (11; 31; 41).

16. A system as claimed in Claim 15, in which the oxidising agent is essentially supplied by the pump device.

17. A system as claimed in Claim 15 or 16, in which the pump device (16; 36; 46) can be adjusted such that the quantity of oxidising agent supplied by the pump device (16; 36; 46) of the fuel cell device (11; 31; 41) effects a constant output of the fuel cell device (11; 31; 41), such that the output of the fuel cell device serves as an output quantity.

18. A system as claimed in any one of Claims 15 to 17 in conjunction with any one of Claims 10 to 13, in which the pump device (16) is designed as a ventilator device for supplying atmospheric air from the environment.

19. A system as claimed in any one of Claims 1 to 18, in which the fuel cell device, the fuel tank device, if necessary the pump device for the fuel and/or for the oxidising agent, is necessary the tank device for holding the oxidising agent and the disposal device are designed as a module which can be inserted into the consumer to supply power and removed from the consumer.

20. A system as claimed in any one of Claims 1 to 18, in which the fuel cell device and if necessary the pump device for the fuel and/or for the oxidising agent is or are arranged on the consumer side, and the fuel tank device, if necessary the tank device for holding the oxidising agent and the disposal device are designed as a module which can be inserted into the consumer to supply power and removed from the consumer.

21. A system (20) for supplying a consumer with electrical power, comprising:

a fuel cell device (21) for generating electrical power,

a fuel tank device (22) for housing the fuel to be supplied to the fuel cell device,

characterised in that

the fuel cell device (21) is provided on the consumer and the fuel tank device (22) is designed as a module which can be inserted into the consumer to supply power and removed from the consumer.

22. A system as claimed in Claim 21 with a pump device (24) provided on the consumer side, preferably a miniature pump, for supporting the fuel supply from the fuel tank device (22) to the fuel cell device (22).

23. A system as claimed in Claim 22, in which the fuel is supplied essentially by the pump device (24).

24. A system as claimed in Claim 22 or 23, in which the pump device (24) can be adjusted such that the quantity of fuel supplied by the pump device (24) of the fuel cell device (21) effects a constant output of the fuel cell device (21), such that the output of the fuel cell device serves as output quantity.

25. A system as claimed in any one of Claims 21 to 24, in which the fuel cell device (21) is designed as a hydrogen fuel cell device.

26. A system as claimed in any one of Claims 21 to 25 with a pump device (26) provided on the consumer side, preferably a miniature pump, for supporting the supply of the oxidising agent to the fuel cell device (21).

27. A system as claimed in Claim 26, in which the supply of the oxidising agent is essentially supplied by the pump device.

28. A system as claimed in Claim 26 or 27, in which the pump device (26) can be adjusted such that the quantity of oxidising agent supplied by the pump device

(26) of the fuel cell device (21) effects a constant output of the fuel cell device (21), such that the output of the fuel cell device serves as an output quantity.

29. A system as claimed in any one of Claims 26 to 29, in which the pump device (26) is designed as a ventilator device for supplying atmospheric air from the environment.

30. A fuel cell device (50) comprising at least one fuel cell device with

a plurality of anode devices (51), and

a plurality of cathode devices (52), such that a corresponding anode device is assigned to each cathode device,

characterised in that

each fuel cell device has a substantially flat electrolyte device (55), such that each anode device (51) and its corresponding cathode device (52) are arranged on opposite sides of the electrolyte device.

31. A fuel cell device (90) comprising at least two fuel cell devices (90a, 90b) each having

a plurality of anode devices (91),

a plurality of cathode devices (92), such that a corresponding anode device is assigned to each cathode device, and

a plurality of electrolyte devices (95), such that

each anode device (91) and a corresponding cathode device (92) are arranged on opposite sides of a corresponding electrolyte device (95) and together form a single cell, and

all single cells of a fuel cell device are arranged on one plane.

32. A fuel cell device as claimed in Claim 30 or 31, in which corresponding anode devices (51) and cathode devices (52) are the same size and shape.

33. A fuel cell device as claimed in any one of Claims 30 to 32, in which ion-permeable, preferably proton-permeable, current conductors (56d), which are interconnected by a connection device, are provided between the electrolyte device(s) and the anode devices and/or between the electrolyte device(s) and the cathode devices.

34. A fuel cell device as claimed in any one of Claims 30 to 33, in which fuel-permeable or oxidant-permeable current conductors (86), which are interconnected by a connection device, are provided on the anode devices and/or the cathode devices.

35. A fuel cell device as claimed in any one of Claims 30 to 34, in which fuel-permeable or oxidant-permeable current conductors (116), which are interconnected by a connection device, are provided in the anode devices and/or in the cathode devices.

36. A fuel cell device as claimed in any one of Claims 33 to 35, in which each current conductor (56d; 86; 116) has a braid or a perforated film.

37. A fuel cell device as claimed in any one of Claims 33 to 36, in which each current conductor comprises nickel, gold, platinum and/or stainless steel.

38. A fuel cell device as claimed in any one of Claims 33 to 37, in which each current conductor (56d; 86; 116) is approximately the same size as the anode device assigned thereto or the cathode device assigned thereto.

39. A fuel cell device as claimed in any one of Claims 33 to 38, in which the connection device strip comprises conductors.

40. A fuel cell device as claimed in Claim 39, in which the strip conductors (54) are applied to the electrolyte device.

41. A fuel cell device as claimed in Claim 39 or 40, in which the connection device comprises a strip conductor for at least one anode device (56a; 66a) and a strip conductor for at least one cathode device (56b; 66b), such that the strip conductors are connected at the edge of the electrolyte device to a connector (67a; 67b).

42. A fuel cell device as claimed in any one of Claims 39 to 41, in which the connection device for at least one anode device and at least one cathode device comprises a strip conductor (56c) which is guided from the anode side to the cathode side by the electrolyte device.

43. A fuel cell device as claimed in any one of Claims 33 to 42, with a switch device (69) which is designed to modify the connection device of the anode devices and the cathode devices of at least one or at least two fuel cell devices, so that the electrical output generated by the fuel cell device can best adapt (U, I) to the requisites of a consumer.

44. A fuel cell device as claimed in Claim 43 in conjunction with Claim 41, in which the switch device (69) has a connector which can be connected to the connector at the edge of the electrolyte device.

45. A fuel cell device as claimed in Claim 44, in which the connector comprises a plug board or several plug boards.

46. A fuel cell device as claimed in any one of Claims 30 to 45, in which the electrolyte device is provided in the form of a proton-conducting electrolyte film.

47. A fuel cell device as claimed in any one of Claims 30 to 46, in which the fuel cell devices are methanol fuel cell devices, and the electrolyte device comprises nafion.

48. A fuel cell device as claimed in any one of Claims 30 to 46, in which the fuel cell devices are hydrogen fuel cell devices, and the electrolyte device comprises nafion.

49. A fuel cell device as claimed in any one of Claims 30 to 48, in which the fuel cell devices are manufactured by surface-coating processes, preferably semi-conductor technology processes and/or electroplating processes

50. A fuel cell device (80; 90) as claimed in any one of Claims 30 to 49 with at least two fuel cell devices (80a, 80b, 80c), in which each two adjacent fuel cell devices (80a, 80b or 80b, 80c) are interconnected by an electrically insulating connection device (88a or 88b), such that

each two adjacent fuel cell devices (80a, 80b) are arranged such that the anode devices (81) of the first of these fuel cell devices (80a) are facing the anode devices (81) of the second of these fuel cell devices (80b), and/or the cathode devices (82) of the first of these fuel cell devices (80b) are facing the cathode devices (82) of the second of these fuel cell devices (80c), and

each connection device (88a or 88b) has a supply distribution structure (89a or 89b) for the fuel (B) to be supplied to the anode devices or the oxidising agent (O) to be supplied to the cathode devices.

51. A fuel cell device (70) as claimed in any one of Claims 30 to 49 with at least two fuel cell devices (70a, 70b), in which each two adjacent fuel cell devices (70a, 70b) are interconnected by an electrically insulating connection device (77a), such that

each cathode side (72) of a first of the two adjacent fuel cell devices (70b) of the anode device (71) is facing the second of the two adjacent fuel cell devices (70a), and

each connection device (77a) has a first supply distribution structure (79a) for the fuel (B) to be supplied to the anode devices (71) and second supply distribution structure (79b) for the oxidising agent (O) to be supplied to the cathode devices (72).

52. A fuel cell device as claimed in Claim 51, in which the connection device (107) has conducting elements (110a; 110b) which are arranged such that it electrically conductively connects each anode device (101) of a first of two adjacent fuel cell devices (100a) to the cathode device (102) facing it of the second of two adjacent fuel cell devices (100b).

53. A fuel cell device as claimed in any one of Claims 50 to 52 in conjunction with Claim 39, in which the strip conductors are provided on or in the connection device.

54. A fuel cell device as claimed in Claim 53, in which the connection device comprises a strip conductor for at least one anode device and a strip conductor for at least one cathode device, such that the strip conductors are connected at the edge of the connection device to a connector.

55. A fuel cell device as claimed in any one of Claims 50 to 54 with a casing in which the fuel cell device is accommodated, in which the connector extends through a wall of the casing

56. A fuel cell device as claimed in any one of Claims 30 to 55, which is designed as a low-temperature fuel cell device.

57. A fuel cell device as claimed in any one of Claims 30 to 56, which is designed to output less than one kW.

58. A system as claimed in any one of Claims 1 to 29, comprising a fuel cell device as claimed in any one of Claims 30 to 57.

FUEL CELL SYSTEM AND FUEL CELL FOR SUCH A SYSTEM

Abstract

The invention relates to a system for supplying a consumer with electrical power having a fuel cell device and a fuel tank device for holding fuel to be supplied. The invention is characterised by a disposal device for accommodating the waste products resulting from the fuel cell device being operated. The invention also relates to a fuel cell device, comprising at least one fuel cell device with a plurality of anode devices, and a plurality of cathode devices, such that a corresponding anode device is assigned to each cathode device. The fuel cell device according to the present invention is characterised in that each fuel cell device has a substantially flat electrolyte device, such that each anode device and its corresponding cathode device are arranged on the opposite sides of the electrolyte device. According to the present invention a fuel cell device is also created having at least two fuel cell devices with a plurality of anode devices, a plurality of cathode devices, such that a corresponding anode device is assigned to each cathode device, and a plurality of electrolyte devices, in which each anode device and a corresponding cathode device are arranged on opposite sides of a corresponding electrolyte device and together form a single cell, and all single cells of a fuel cell device are arranged on one plane. By way of advantage such a fuel cell device comprises at least two fuel cell devices, such that each two adjacent fuel cell devices are interconnected by a connection device and each connection device has supply ducts for the fuel to be supplied to the anode devices or the oxidising agent to be supplied to the cathode devices. Alternatively, such a fuel cell device comprises at least two fuel cell devices, such that each two adjacent fuel cell devices are interconnected by a connection device, and each connection device has first supply ducts for the fuel to be supplied to the anode devices and second supply ducts for the oxidising agent to be supplied to the cathode devices.

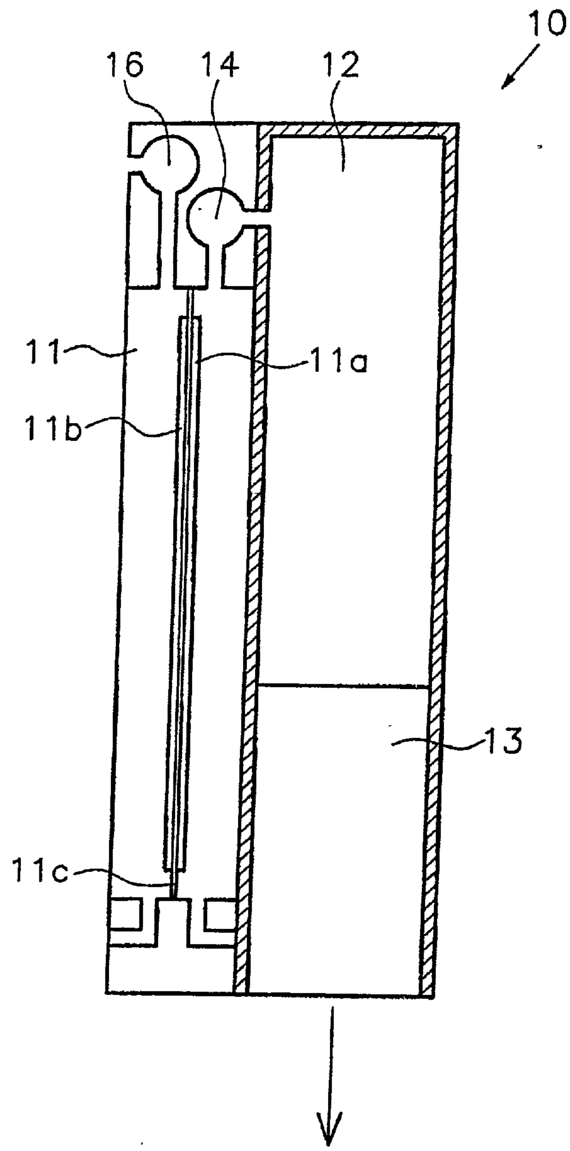

FIG. 1

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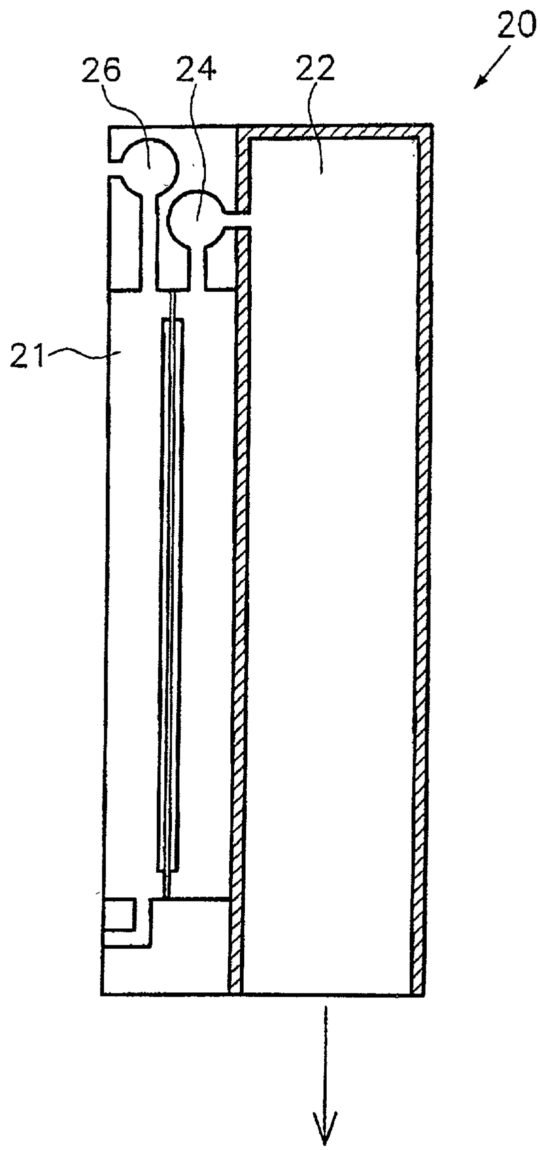

FIG. 2

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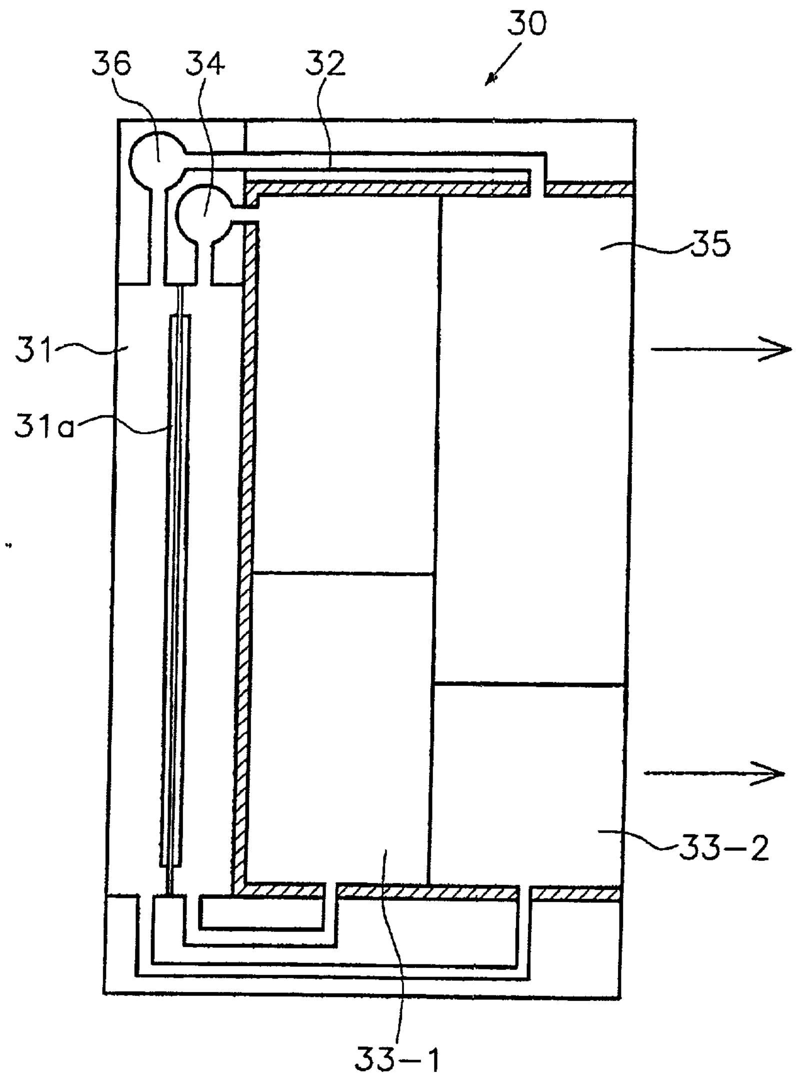

FIG. 3

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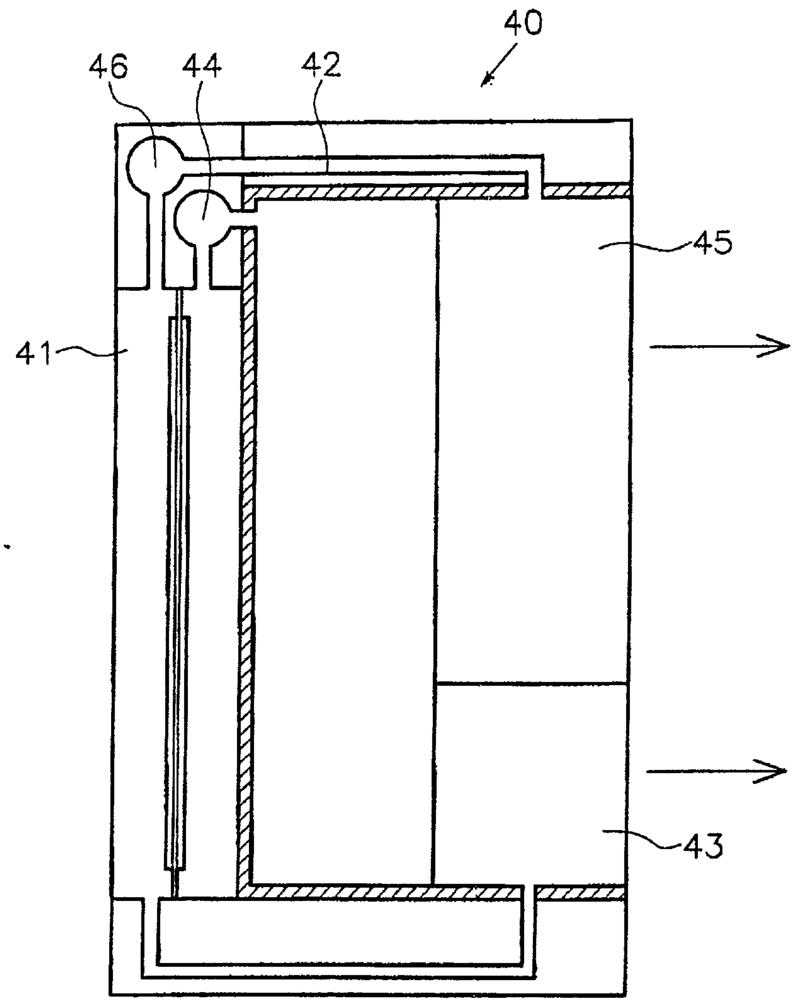

FIG. 4

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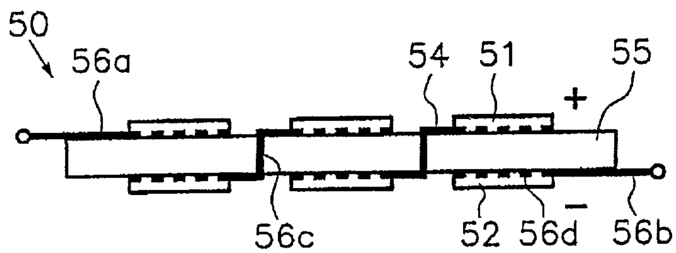

FIG. 5

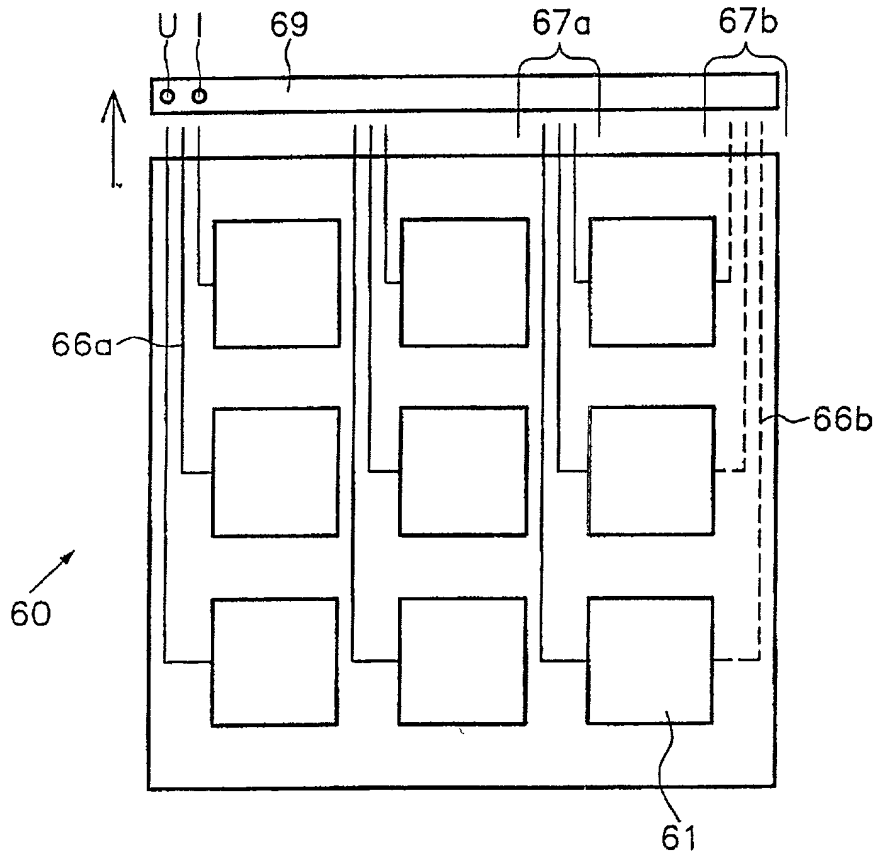

FIG. 6

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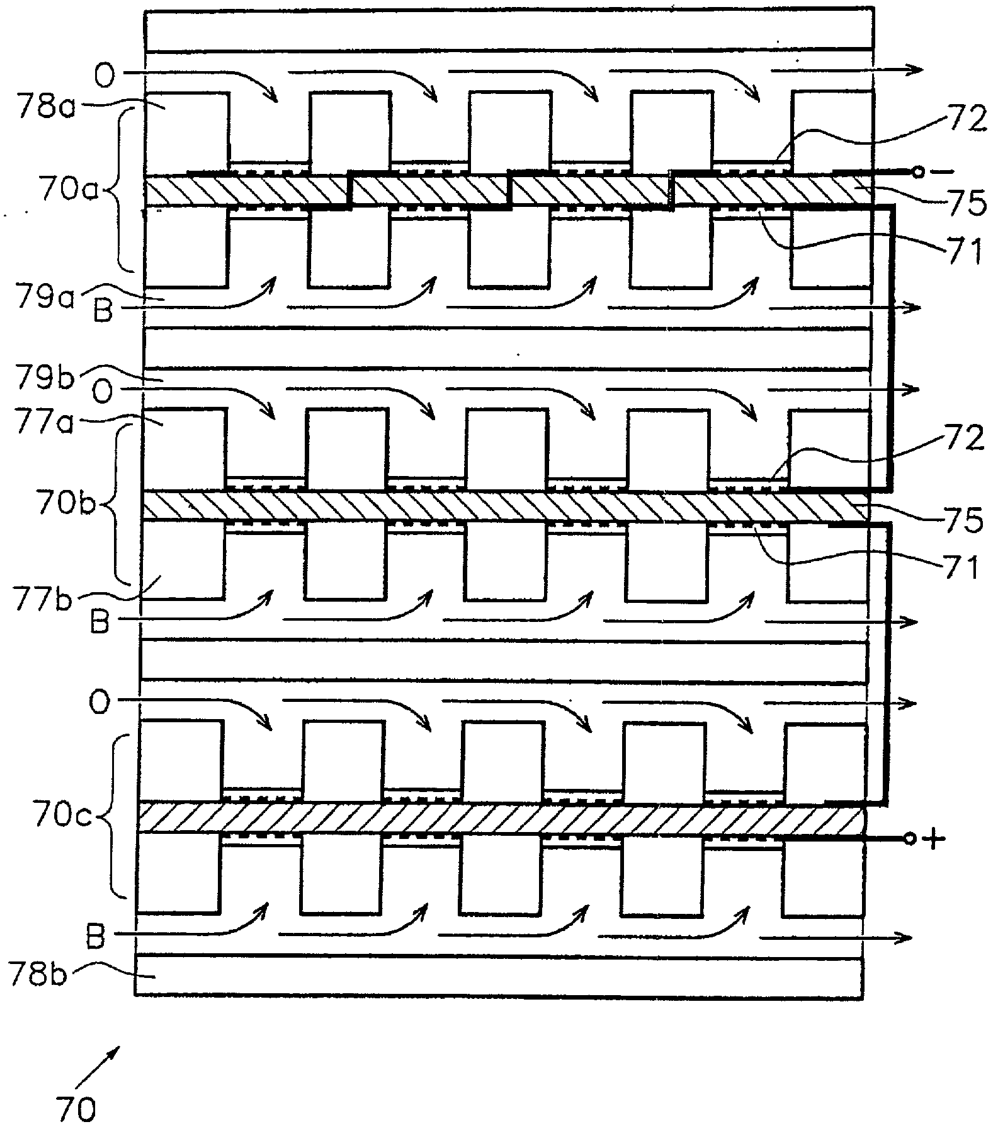

FIG. 7

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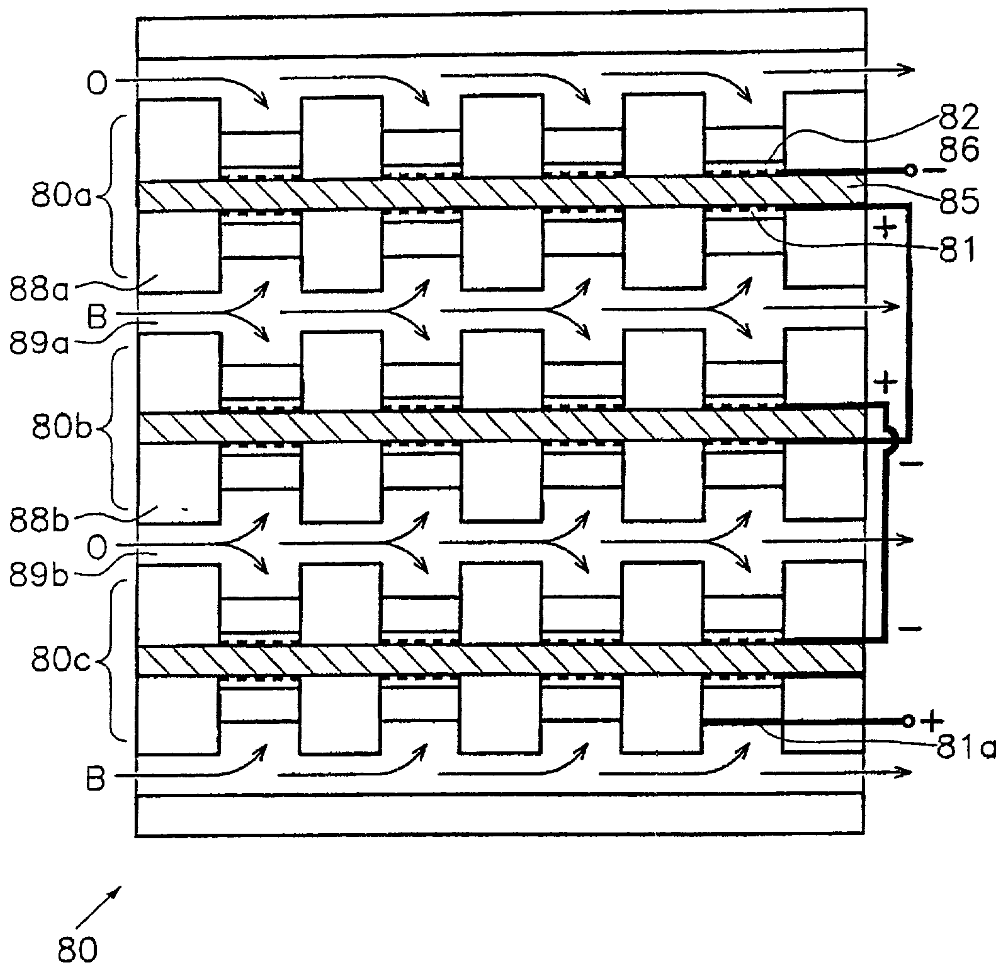

FIG. 8

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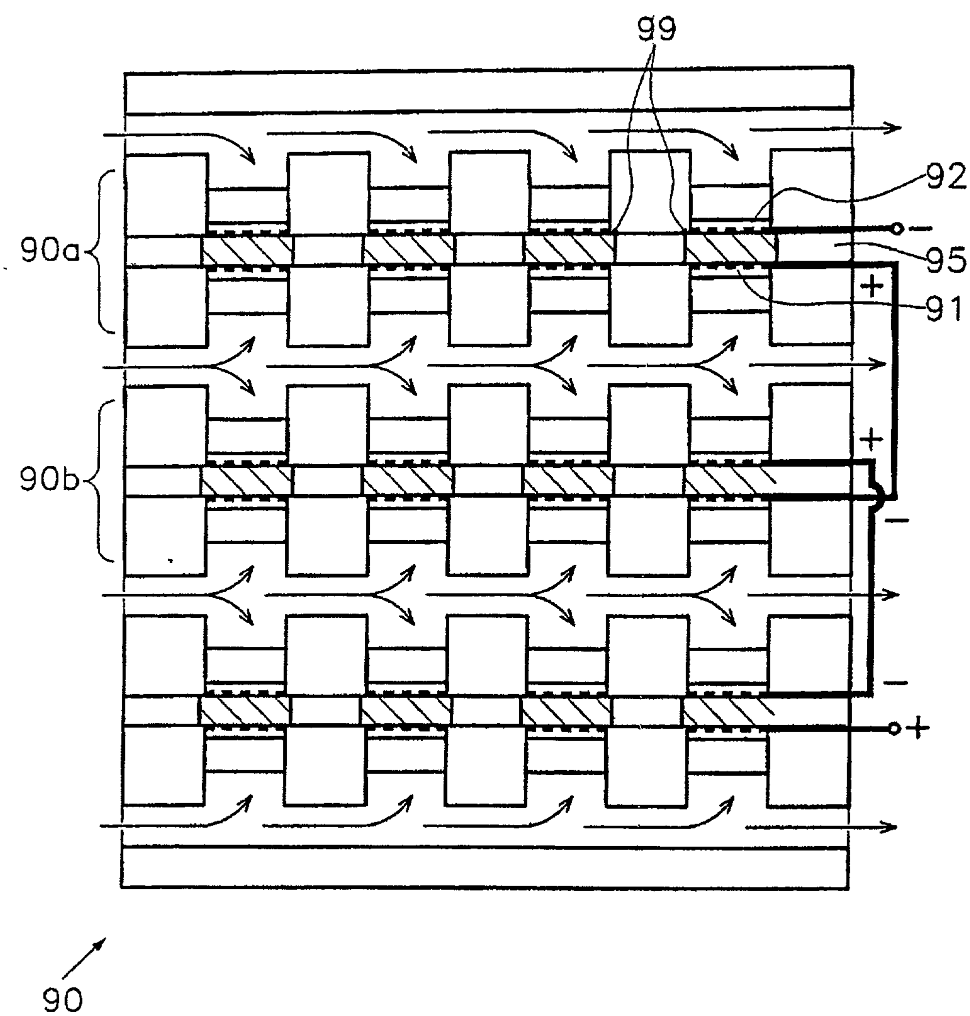

FIG. 9

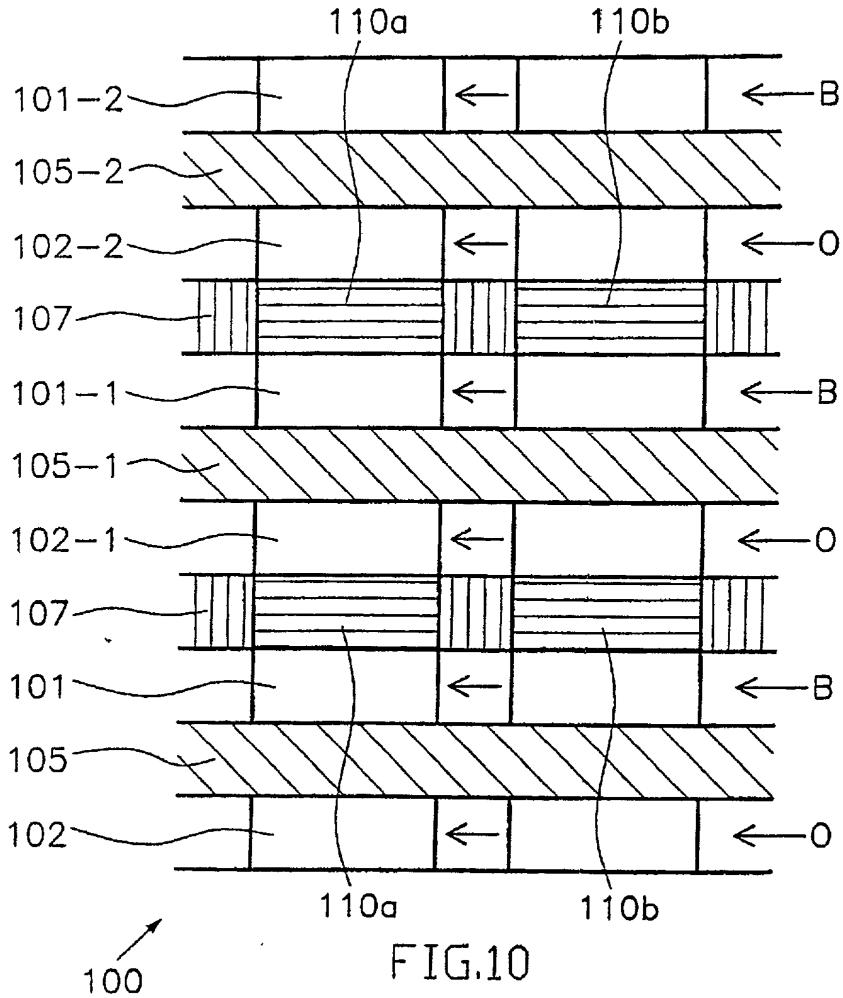
110a
110b
101-2
105-2
102-2
107
101-1
105-1
102-1
107
101
105
102
B
O
B
O
B
O
110a
110b
100

FIG.10

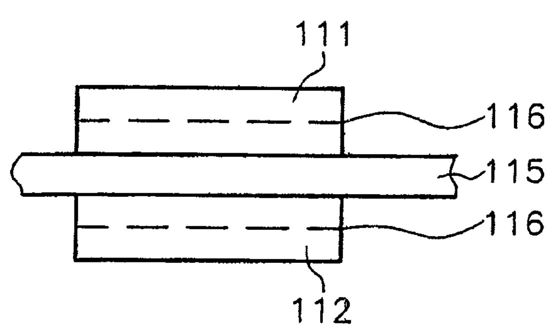
111
116
115
116
112

FIG.11

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below under my name.

I believe that I am an original, sole and or joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled

APPARATUS AND METHOD FOR RAISED AND SPECIAL EFFECTS PRINTING USING INKJET TECHNOLOGY

the Specification of which

☐ is attached hereto
☒ was filed on **June 8, 2000**
as United States Application Number or PCT International
Application No. **PCT/IL00/00342**
and was amended on ____________________ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified Specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, 1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any provisional application filed in the United States in accordance with 35 U.S.C. §1.119(e), or any application for patent that has been converted to a Provisional Application within one (1) year of its filing date, or any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed.

PRIOR FILED APPLICATION(S)

APPLICATION NUMBER	COUNTRY	(DAY/MONTH/YEAR FILED)	PRIORITY CLAIMED
60/138,541	**US**	**10 June 1999**	
PCT/IL00/00342	**PCT**	**8 June 2000**	**Yes**

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application listed below, and, insofar as the subject matter of each of the claims of this application is not disclosed in any prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined

DECLARATION, Page 2 of 2 STEFENER et al. 10/018,319

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ZIP/Postal Code Citizenship

300

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Given Name(s) Family Name or Surname
4-19-2002
Inventor's Signature Date

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City State Country
D-81479 GERMANY
ZIP/Postal Code Citizenship

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DECLARATION FOR UTILITY PATENT APPLICATION (37 CFR 1.63)/POWER OF ATTORNEY

First Named Inventor: STEFENER, **Attorney Docket Number:** GRUNP117
Application Number: 10/018,319 ☒ Declaration Submitted with Initial Filing
Filing Date: 11/13/2001 ☐ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)
Group Art Unit:
Examiner Name:

RECEIVED APR 25 2002 TC 1700

As a below named inventor, I hereby declare that:
My residence, mailing address, and citizenship are as stated below next to my name.
I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter that is claimed and for which a patent is sought on the invention entitled: FUEL CELL SYSEM AND FUEL CELL FOR SUCH A SYSTEM, the specification of which

☐ is attached hereto.
OR
☒ was filed on 11/13/2001 (MM/DD/YYYY) as U.S. Application Number or PCT International Application Number 10/018,319 and was amended on ______ (MM/DD/YYYY) (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information that is material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information that became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or (f), or 365(b) of any foreign application(s) for patent, inventor's or plant breeder's rights certificate(s), or 365(a) of any PCT international application that designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent, inventor's or plant breeder's rights certificate(s), or any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Foreign Filing Date (MM/DD/YYYY)	Country	Priority Not Claimed	Certified Copy Attached? YES	NO
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐

I hereby appoint Thomas M. Champagne (Reg. No. 36,478); Paul W. Koda (Reg. No. 44,191); and George F. Wallace (Reg. No. 45,286) as attorneys to prosecute the application identified above, and to transact all business in the United States Patent and Trademark Office connected therewith.

Please direct all correspondence to:

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